ENGINEERING SERIES

EDITED BY

ANDREY A. POTTER, Eng.D.

DEAN OF THE SCHOOLS OF ENGINEERING, AND
DIRECTOR ENGINEERING EXPERIMENT
STATION PURDUE UNIVERSITY

THE ELEMENTS OF INDUSTRIAL ENGINEERING

BY

GEORGE HUGH SHEPARD
PROFESSOR OF INDUSTRIAL ENGINEERING AND MANAGEMENT
PURDUE UNIVERSITY, LAFAYETTE, INDIANA

GINN AND COMPANY
BOSTON · NEW YORK · CHICAGO · LONDON
ATLANTA · DALLAS · COLUMBUS · SAN FRANCISCO

1923

PRINTED IN THE UNITED STATES OF AMERICA

428.4

The Athenæum Press
GINN AND COMPANY · PRO-
PRIETORS · BOSTON · U.S.A.

PREFACE

In the preparation of this work the writer had three distinct purposes: (1) to reduce industrial engineering to a few definite and comprehensive principles, by which the engineer can analyze any situation in management and synthesize the procedure; (2) to bring students immediately into working contact with these principles; and (3) to cause them to learn the principles practically by using them in their daily lives.

Since it is necessary that students should acquire practical knowledge of the principles as soon as possible, the discussion of the application of the principles to their present activities is placed near the beginning of the book.

This book teaches no cut-and-dried system. Its distinctive features are that it teaches the student to analyze every management situation and synthesize procedure by the Principles of Management; and that it uses the student's daily life, especially the campus activities, to start him in the acquisition of the necessary experience. Skill in analysis and synthesis by the Principles of Management, and the operating skill which the student must acquire by his own experience, prepare him to deal with any problem of management.

Instruction may be regarded as a seed sown in the student's mind. A seed contains a germ of life, the embryo plant, and food on which the young plant must live until it can grow roots and leaves and extract its own nourishment from the soil and the air. The life germ, a very small part of the seed, is the vital essential. In this book the meaning and use of the Thirteen Principles of Management are the vital germ, while the much larger bulk of information is merely the mental food on which the embryo industrial engineer is to live until he develops into the practicing engineer and lives on his own knowledge and skill.

A good deal of the matter of this book was published in the writer's "Application of Efficiency Principles," by the Engineering Magazine Company, and is herein used by their permission.

G. H. S.

CONTENTS

THE ELEMENTS OF INDUSTRIAL ENGINEERING

CHAPTER I

INTRODUCTION

1. An engineer's start. The engineering student looks forward to the time when, as a graduate, he will begin his professional career. If his first position is that of a draftsman, he will make pencil drawings only, while less skilled workers will trace his drawings and make the blue prints.

In whatever way he may begin, something similar will happen. The skilled man costs too much to be allowed to waste his time on work beneath his skill. That will be taken from him to be done by less skilled assistants.

Usually the engineer has to control his own assistants, to supply them with work, and to see that they do it efficiently. That means management.

2. Executive ability essential to success. If the young engineer shows ability in the management of his first few assistants, larger managerial opportunities are likely to open to him, but if in this position he shows lack of ability to manage, his superiors are not likely to promote him when the next higher position is vacant. Moreover, as the engineer rises in his profession, with every advance the duties of management have a larger and larger relative importance, until the men in the highest and best paid positions are usually acting exclusively as managers. The technical details are delegated to their subordinates.

The student should therefore realize that executive ability, that is, the ability to manage, is almost sure to be a vital factor in his professional progress.

3. Management always necessary. The student should realize further that ability to manage cannot be acquired without practice. Study of the subject is very valuable, but without practice it will never give the correlated readiness which is necessary to operating skill.

Furthermore, every man who is not so incompetent as to be legally under the care of a guardian is obliged to manage to some extent, — at least to manage his own affairs.

All management, from that of an ant hill to that of the universe, is based upon and applies a few fundamental principles.

Therefore the student should not look upon the study of management as something about which he is to store his mind with information to be kept latent until at some future time his activities demand its use, but he should realize that management is an activity which is demanded of him every hour. He should realize that he may even now wisely and skillfully employ on a small scale the principles that govern the conduct of a captain of industry or a chief of state. In the measure in which he applies these principles on a small scale he will gain ability to use them on a larger scale, and the demonstrated ability to manage on a small scale is most likely to bring him the opportunity to manage on a large one.

Moreover, to manage himself wisely is essential to any personal efficiency and therefore to personal success, and is something that will always be demanded of him, no matter how high he may rise.

4. Management of student activities. While the student's personal affairs are a field in which small-scale ability in management may be acquired, it is desirable that from the very beginning of his college course he should seek other and larger opportunities for management. Athletics, fraternities, and other student societies, glee clubs, dramatic societies, and class organizations, all require student managers. The student who desires to develop his executive ability should seek such managerial work. Many American schools have military departments, and as a cadet noncommissioned or commissioned officer the student will get very valuable experience as a manager.

5. Experience in industry. While the student body of a college is a little world in itself, there is about its affairs a certain air of make-believe which makes it desirable that the student, even

during his college days, should gain experience of the world of stern reality. He is therefore strongly advised to engage in practical engineering work during the summer vacations at least. If his work is that of a straw boss or other minor executive, so much the better from the managerial point of view, but in any event he should bring himself into contact with actual work and workers. He should at the same time study management, remembering that much of the management that he will see in industry is bad, and that he must study to correct its errors as well as to appropriate to himself its virtues.

CHAPTER II

THE PRINCIPLES OF MANAGEMENT

6. The Thirteen Principles of Management. Harrington Emerson first stated twelve definite principles as the fundamental causes of all efficiency. His statement of these twelve principles resulted from his study of many thousand experiences in management; in every case the observed results were traced to their fundamental causes, in so far as those causes lay within the field of management.

The following table of the Principles of Management is derived and somewhat modified from Harrington Emerson's Twelve Principles of Efficiency. It is therefore similar to the table of the chemical elements, in that it summarizes the knowledge derived from an analysis of experience and in that further experience may modify it to an extent which cannot now be foreseen.

THE THIRTEEN PRINCIPLES OF MANAGEMENT

ALL-INCLUSIVE	PRIMARY	SECONDARY
	Ideals	Adaptation of conditions and work to each other
		Correct Methods
		Instruction
Higher Common Sense	Personnel	Fair Deal
		Discipline
		Planning and Despatching
		Records
	Organization	Standards
		Efficiency Reward

In so far as the experience in management from which the table above is derived adequately represents the whole field, we are warranted in saying that all management consists in the application of these principles. Keeping our minds open for further knowledge, we are warranted, while awaiting such knowledge, in using these principles as a working approximation.

7. The primary principles. It is reasonable to suppose that some few of the principles, like the primary colors of the spectrum, potentially contain all the rest, but it is not so easy to determine which these are. In January, 1913, the writer was sent to the Pittsburgh and Lake Erie Railroad to collect data for the series of articles on that road which Harrington Emerson was then writing for the *Engineering Magazine.* He found there a very high efficiency and found also that only three of the principles had been consciously recognized. There was a very remarkable personnel, scientifically organized and pursuing correct Ideals. Personnel, Organization, and Ideals had been strongly applied; and it was evident that a selected Personnel, pursuing correct Ideals by means of scientific Organization, had of itself applied all the other principles, for all the other principles were in use.

These three, therefore, are the primary principles. All the colors of the spectrum in a perfect blend make white. Similarly, Personnel, Organization, and Ideals result in the application of all the principles, and we then get the effect of the great, all-inclusive principle, Higher Common Sense.

8. Correct Methods and Instruction; Adaptation. Correct Methods and Instruction combine closely with each other. **Only that which is earnestly studied can be well done. Only that which is practiced can be thoroughly learned.** Therefore Instruction and Correct Methods are inseparable, and are bracketed together in the table on page 4.

We always desire to adapt conditions to the work to be done, but this is not always possible. For example, we cannot so adapt conditions at sea as to make commercially profitable the speed of the railway, and are forced to the slower transportation by ship. So adaptation must work both ways; for if we cannot adapt the conditions to the work, we must adapt the work to the conditions.

9. The ethical principles. While all these principles have a moral aspect, this is so preëminently true of four of them that Emerson gave them the name of the "ethical principles." These are Ideals, Fair Deal, Discipline, and Efficiency Reward. Recent history provides a startling example of the penalty for violating the ethical principles. A nation at the height of power, and renowned for high efficiency, flagrantly violated Ideals and

the Fair Deal. For Ideals of world service she substituted Ideals of world conquest. For the Fair Deal toward other nations she substituted a reversal of the Ten Commandments. When the consequent tremendous expenditure of treasure and of priceless lives is realized to have resulted in her fall from her position of world power in 1914 to her present estate, her efficiency can be evaluated only as minus infinity.

The student should appreciate at the outset that the ethical principles are not only matters of morals, and important for that reason, but that they are just as much tools for the manager's daily use and as essential to his success as any others.

The severest criticisms of efficient management arise from ignorance of the ethical principles. One often reads statements that, although the immediate economic effects may be valuable, the moral effects are always harmful and the ultimate economic effects disastrous. If the critic states his reasons, analysis will reveal complete ignorance of the ethical principles.

10. Diversity of conditions and methods. Every problem has its own peculiarities which result in wide differences of methods and devices. Hence a mere statement that such and such things have been done in some plant is in itself of very little value. One who devotes his efforts to searching such records for things which he himself can use is apt to be like the stutterer who practiced "Pickled peppers" until he could say it perfectly; but, as he complained, "It s-s-so s-s-eld-d-dom oc-c-c-urs in c-c-c-conversation."

On the other hand, every one of the principles listed above applies to every management problem, even if the specific cases be as various as a hospital, a school, a church, a factory, and a department store.

11. Example of application of the principles. An analysis of any case of very high efficiency will show all the Thirteen Principles in use. As the basis of problem 11, p. 33, is given a statement from Arnold's "Ford's Methods and the Ford Shop" of "How Ford makes a Commutator." The student should note in the margin of this statement the different Principles of Management, as the statement shows their application. If he finds this problem too difficult at this stage, he may defer it until he has studied the explanation of the meaning of the principles given in sections 22-33.

12. No universal system. In an effort one time to increase the efficiency of a gang of workmen, conditions had been adapted, standards had been determined, their work had been planned and despatched, records had been installed, and efficiency rewards had been applied by offering a bonus above their previous time rate for any increase in their efficiency. At this point progress was blocked by a violation of the principle of Ideals by the boss, who held that limitation of production was necessary for his protection. To apply the apparently obvious principle of Instruction and teach the economic fallacy of limitation of production would with most workers be useless. Instead, the principle of the Fair Deal was applied. Occasionally the gang would make a good enough efficiency to earn a little bonus. Just as soon as they found that they had done this, they would drop to a very low efficiency. The boss was afraid, in fact, to make a good efficiency because, as he plainly stated, he believed that as soon as he did so the bonus would be withdrawn, and he would be driven to make the same efficiency on his bare time rate on pain of losing his job. However, the bonus attracted the gang; and after a while they would slowly come up to a good efficiency, only to slump again as soon as they found that they had earned bonus. Their conduct was like that of wild animals approaching food while fearing a trap. Every time the gang earned bonus it was paid them, and none of their standards was made more severe. On the contrary, a considerable number of standards that were found to be too severe were made easier. After experiencing this kind of treatment for nearly three months, the gang acquired confidence, and thereafter worked continuously at a high efficiency. Continuous practice of the Fair Deal won in the end.

An alternative course would have been to apply the principles of Discipline and Personnel, and to replace the original gang by men who would have been more willing to produce results; but the men were to some extent justified in their suspicions by the fact that the management had at former times yielded to the temptation to cut piece rates on which it considered that excessive earnings had been made. Hence the Fair Deal required that these men should be allowed to satisfy themselves of the management's good faith in their own way.

As in the case above, every one of the principles is continually

mixing with all the rest. While one is earnestly applying one, he may at any time be confronted by the need of the application of others. Hence the only guide through the mazes of management is the knowledge of all the principles.

If the student has expected to find management some cut-and-dried routine system which he can apply in machine fashion, he should at once abandon that idea absolutely. **There is no universal system.** Management situations are infinite in number and variety, and a manager can deal with them only by doing his own thinking on the basis of a thorough knowledge of fundamental principles.

To ask the industrial engineer for a definite statement of procedure is like asking the navigator what course he steers at sea, and as little admits of a general answer. The navigator can lay a definite course for any voyage, but he does so by applying the principles of navigation. So the industrial engineer can define procedure in any situation, but he does so by applying the Principles of Management.

Moreover, while a study of any experience in management usually yields but little in the way of methods that can be directly applied to any other case, the analysis of any such experience into the application of fundamental principles — as in the case of the Ford commutator, problem 11, p. 33 — will always yield something of value in deeper and more thorough knowledge of the principles themselves, and of greater skill in their application to any case that may arise.

Furthermore, as appears in the example cited above in this section, the principle which comes first to mind as applicable is not always the one that will produce results. The only way that errors of this kind can be avoided is by the continual study of one's own experiences and those of others in the light of the principles. The words of Dr. J. G. Schurman, former president of Cornell University, "Practice without theory is blind, and theory without practice is empty," apply strongly to management.

13. Interrelation of the Principles. Because of the interplay of the principles with one another it is impossible even to discuss any one of them without bringing in the others. Hence it is necessary, before discussing any principle in detail, to give a general statement of all of them.

On the other hand, any general analysis, either of theory or practice, must proceed in the main along the line of one principle at a time. These chapters therefore discuss each principle in turn. However, adherence to any one principle only, to the neglect of others, is sure to get the manager into trouble, safety and success lying in the simultaneous practice of all.

Section 203 tells how, in a shipyard during the World War, inability to apply Standards, Records, and Efficiency Reward adequately was partly compensated by a very strong application of Ideals. This is typical, because **poor application of some principles may usually be at least partly compensated by strong application of others.**

14. Analysis and synthesis by the Principles of Management. A certain foreman had difficulty in keeping workmen in his department. The men were on piecework, and the management made a practice of watching their earnings and of cutting any piece rate on which it considered that more than a fair rate of pay had been earned. The result was that most of the men were unable to earn enough on the reduced piece rate, and they would quit. In order to keep from losing his men in this way, the foreman spent much of his time in watching the more efficient men and bothering them sufficiently to keep their earnings low enough so that the rates would not be cut. He would even discharge a workman if he persisted in doing enough work to cause danger of a cut in the piece rate.

Considering this case, we see at once a violation of the Fair Deal, Efficiency Reward, Discipline, and Common Sense.

On further investigating this case, it was found that the false Ideal of limitation of production was so general throughout the plant that superintendents and foremen told their men not to do too much. In fact, owing to this cause, production was about 30 per cent below what it might have been.

It is evident that the root of the whole trouble was the violation of the Fair Deal by the management, but the application of the Fair Deal was not the only step necessary. Back of that lay the fact that there were no proper Standards. Having no Standards, the management had tried to set its piece rates by guess and then to correct errors by cutting any rate that appeared to result in excessive earnings. This practice is very common and always results in limitation of production by the

workers, who, realizing that they will be allowed to earn only so much, determine to get it as easily as possible.

The necessary steps were to determine Standards scientifically, to apply the Fair Deal by sticking to them, and then to provide Efficiency Reward by paying for good efficiency as determined by comparison with them.

This case is an example of the fact that the Principles of Management furnish a systematic Correct Method for the investigation of any management problem.

It may be necessary at any stage of management (and it is practically always necessary at the beginning of one's experience in it) to examine formally the existing conditions by comparison with every one of the Principles of Management. A suggested outline for such examination follows:

How does this practice accord with higher common sense?
What are the ideals?
Is the personnel suitable?
What is the organization?
Are the conditions and work adapted to each other?
Are the methods correct?
Has the personnel been instructed?
Is there a fair deal?
Is there discipline?
Is the work planned and despatched?
Are there proper records?
Are there correct and adequate standards?
Is efficiency rewarded?

The difficulty of answering any one of these questions may necessitate the acquiring of further information. The best, quickest, and least expensive means is the one to use for the purpose. In industry that is so commonly the time study that an example of one for this purpose is given in Table XIV (see section 322).

Of course, as one becomes skilled, such analysis by the fundamental principles becomes more and more instantaneous and subconscious, just as during the process of learning to read the first slow process of spelling out every word letter by letter gradually gives place to the rapid recognition of each word as a whole, in which there is no conscious thought of the letters.

As soon as analysis shows which Principles of Management are not applied or are violated, application of these principles will indicate the proper procedure. They thus become the means of synthesizing the course of action to be followed.

The use of the Principles of Management for analysis and synthesis, thereby making them a continual guide in management, is the gist of the whole subject. The student should not leave this section without realizing the importance of this use of the principles, and he should continually strive for skill in it.

In order that he may not fail to get the lesson in this section, he is advised to stop at this point and apply it to some management problem in which he is interested; for example, the results of some past athletic season or the prospects for a future one.

The student is strongly recommended, in order to develop skill, to schedule a reasonable part of his time regularly (see section 17) for the analysis, by the Principles of Management, of any management situation with which he may be in contact (the management of his private affairs, if nothing larger offers) and for the synthesis of the courses of action indicated for the future.

15. Order of study. Since management requires the constant and simultaneous practice of all the principles, the order in which they are studied is immaterial. There is no reason why the reader should not take up the several principles as he may find interesting or convenient for his own needs. Because of the close interrelation of the Principles, it is necessary to give in many sections cross references to others that bear on the same point.

BIBLIOGRAPHY

EMERSON, HARRINGTON. Twelve Principles of Efficiency. The Engineering Magazine Company.

SHEPARD, GEORGE H. The Application of Efficiency Principles. The Engineering Magazine Company.

CHAPTER III

CAMPUS ACTIVITIES AS PART OF A STUDENT'S EDUCATION

16. The problem. Many college students regard campus activities as of greater value in their preparation for life than their studies. While this idea is questionable, teachers fully realize the value of such activities among students as a preparation for right living and for work with others. On the other hand, many students find the campus activities altogether too absorbing, and their studies suffer in consequence.

The problem, then, which the student has to solve, in making these activities a real part of his education, is to strike the right balance between them and his studies. The correct balance is a matter of time; that is, of the proper division of time between the two.

17. The student's schedule. A practical and — after one has become used to it — an easy way to solve this problem is always to keep one's time planned ahead according to a definite schedule.

The faculty provides the student with the basis of this schedule in the routine of classes. Starting with this as a foundation, the student should next assign adequate time to prepare lessons and to write reports and notes on lectures. The preparation should be planned as nearly as possible immediately before the class, and the writing as nearly as possible immediately after.

Next should be assigned time for the development of character, including attendance at religious services, attention to duties to parents (such as correspondence), and service to the community (which in the student's case will probably be the student community). The last will include attendance at meetings of the student body, service on college tag days, and the many other things which the public-spirited student does for the benefit of his school, his college mates, and his fraternity.

The next things to which adequate time must be assigned are sleep and meals. In general, students at the writer's own insti-

tution do not sleep enough. At the usual age of college students one needs eight hours of sleep, on the average, out of every twenty-four. At that age one has the greatest resistance to fatigue and may sleep less without feeling immediate bad effects, but not without impairing one's powers in later life. Getting too little sleep in youth is drawing on one's physical principal, instead of living on the income.

The next thing to schedule is time for some definite student, or campus, activities. These may combine with other objectives: with mental development, through membership in the literary, scientific, technical, professional, and honorary societies among the student body; with development of character, through participation in the religious and ethical organizations of college or town; or with physical exercise, through taking part in athletics. Whatever the form of activities selected, in order to accomplish their purpose as a part of one's education they should bring one into contact with his fellow beings, give an opportunity to study them and learn how to deal with them, give some experience in the social amenities, and give at least a small-scale experience in the management of affairs. As the student becomes available, by reason of his academic advancement, for positions which involve managerial responsibility, he should seek these and make good in them. Even activities which at first glance do not look promising in these respects may yield a large return if an effort is made to develop their possibilities. For example, the athlete who is not merely one from his neck down, but who also uses his head, can learn much by observing the management of the athletic department and of his own team, the generalship of the team during a contest, the coach's ways of dealing with the players, and psychic as well as physical ways of handling opponents. What, for example, keeps up the courage and morale of the team? How may that of his opponents be undermined? And how far is such a practice consistent with true sportsmanship, that is, with the Fair Deal?

The working student may be forced to study and develop the possibilities of his work itself to afford him the necessary contact with men and women, to enable him to study people and learn how to deal with them, and to give him at least a small-scale experience in the management of affairs. The

sheer necessity of doing these things in work for one's support may make it more valuable in these respects than any campus activity.

The student who is able to take part in campus activities, and who finds them interesting, must guard against undertaking too many of them. This is especially the case with the student who is both able and popular. It is likely to require much moral courage for him to refuse, under the pressure of his college mates, to undertake altogether more than he can accomplish. The student should limit his campus activities to those which he can do well and without injustice to the other parts of his education.

Next should come time for physical exercise. The student who is not out for some form of athletics is apt not to take exercise enough, — a statement which applies even more to women students than to men.

For the mental worker physical exercise serves not only for the development of the body but also for the recreation of the mind, and therefore doubly for the maintenance of true health, — a sound mind in a sound body. In order that physical exercise may refresh the mind, and in view of the fact that the time which the mental worker can devote to it must be limited, it is important to select forms of exercise which one naturally finds interesting. Among men physical exercise should also develop courage, both moral and physical. The former is accomplished by always playing fair, by being a true sportsman. The latter end is attained by practicing a contest form of sport with sufficient spice of danger, like football, boxing, or wrestling.

In these latter forms of sports everyone will receive minor and temporary injuries, a very few will suffer serious and permanent injuries, and on rare occasions someone will be killed. Even an occasional fatality is not too great a price to pay for rearing a race of real men. The student and his parents must realize that a youth cannot be developed into a real man without taking some risks. On the other hand, the severe and contest forms of sport will prove too arduous and dangerous for all but a very few men after they reach later middle life. At that time one is carrying his heaviest responsibilities and doing his biggest work, and is of most value to society. It is therefore a matter of duty for the busy man or woman in middle life to

take reasonable care of health. The student should look forward to and make provision for this time of life by cultivating a taste for some of the milder forms of exercise which can be practiced through life.

In view of the effort which is made by American educational institutions to induce all their students to take part in intramural sports, the failure of any student, other than one who is crippled, to find some forms of physical exercise which will meet the needs above stated can be accounted for only on the ground of indifference. An exception may be necessary in the case of a student who is earning his livelihood. It may be necessary for him to study and develop the possibilities of his work itself for affording him the necessary physical exercise and mental change and recreation.

Next on the schedule should come a few hours a week for amusement. A little play in one's routine is as necessary as a little sugar in one's diet. Here is another opportunity to gain experience of those social usages which have so large an effect in determining one's success or failure in later life.

Finally, a few hours every week must be left vacant to be used for those minor matters which cannot be foreseen and which will demand a half-day or so of one's time.

18. Value of the schedule. One of the chief values of the weekly schedule is that after one has learned by a sufficient number of trials how to make a practicable one, it gives the correct balance of one's time. It is probable that even athletics — that absorbing devastator of so many undergraduate careers — would cause very few students to fail if they would confine their attention to it to the hours properly set aside for it. Class failures do not result so much from athletics as from talking about it during study hours. If the student will make a definite schedule of his time and, when study hours come, exercise his will power, shut out other matters, and concentrate on study, the other matters can be given their share of attention, not only without harm but with positive benefit.

Perhaps the student will feel that it is impossible to get so many things into his time. Probably that feeling results from his trying in a haphazard way to do all those things and not succeeding. He should realize that getting his work into his time is a good deal like getting his clothes into his trunk. If he

will stow everything neatly where it belongs, he will be surprised to find how much the thing will hold. That is the second great value of planning one's work ahead: it greatly increases one's powers of achievement.

19. Varying the schedule. Students often become discouraged with personal planning because they find that they cannot rigidly follow any schedule. The standard schedule should be regarded as a convenient point of departure from which such variations should be made as are desirable for temporary reasons. Suppose, for example, that the student wants to go to a dance on an evening regularly scheduled for study and to remain during several of the hours scheduled for sleep. If he has a complete standard schedule, he can shift the required number of hours of recreation and of exercise (taking care not to use his exercise time this way too often) into the time required for the dance, and shift his sleep and study into the time thus made available. One of the advantages of having a standard schedule is the ease with which it enables one to make such shifts.

20. Foresight. Note that in so doing one exercises foresight. The third great value of personal planning is that it causes one to look ahead and to prepare in advance for everything that needs to be done. **This is absolutely necessary to success in life.** The student should not fail before he leaves college to acquire this habit of foresight and of advance preparation.

21. Developing executive ability. The common value of campus activities in education is that they are laboratories for the practice, and therefore the development, of executive ability; that is, the ability to do things and to get things done in the world of men and affairs.

How is a student in playing football, for example, to gain a knowledge of management which will serve him later as manager of a factory? The answer is that all management is the application of the Thirteen Principles, and that by knowledge of and practice with every one of them each principle becomes a tool which he can use in any situation.

The student needs to understand how through campus activities he may become — at least on a small scale — a skilled practitioner of all the principles. To that end he needs now to consider every principle by itself. Since the secondary principles get down closest to concrete facts, it is best to consider them first.

THE THIRTEEN PRINCIPLES OF MANAGEMENT SEPARATELY CONSIDERED

22. Planning and despatching. Personal planning has been explained above. The same foresight, advance preparation, and correlation of events which have been discussed under personal planning are much more important where more persons are involved.

In whatever activity the student may engage, he should note how its events are planned ahead. If its plans are faulty, the student should note what the defects are, what causes them, how these causes may be removed, and what ill effects spring from the faulty plans.

If plans are made and go wrong, the despatching has failed. What is the cause? Very likely a violation of one or more of the other principles; for they are all interdependent.

When the student arrives at a position of management in his selected activity, he should seek in every way to improve its Planning and Despatching. The same thing holds with every one of the Thirteen Principles.

The student is usually a routine worker. Routine calls for the easiest kind of planning, and it is just as well that the student should begin with the easiest problem. As he rises in his profession he is almost sure to have less and less of routine and more and more of initiative. As this change takes place, his personal planning will require more skill and will be more important. The proper bases for the development of such skill are ability as a routine planner and a good memory. With these two requirements he will be able to solve this problem for himself as his career develops.

23. Records. The following is an excellent example of a student's personal application of the principle of Records.

A record of each day's assignment is made in a notebook, at the time the assignment is made in class. A record of all grades is made as soon as papers are returned or as soon as the grade is given out. A record of all financial expenditures is made daily and kept as a permanent record. A record of important events is kept in a daily record in a yearbook. Current funds are kept in a checking account. The records are the check book and the bank's pass book. All bills of any importance are

paid by check. Valuable papers are kept in a safe-deposit box in a bank. Letters and less important papers, including examination papers, are filed in a large letter file under a standard filing system. Receipted bills and canceled checks are kept in a special file. Blue prints and drawings are kept on a hanging file, so that any drawing is immediately accessible and the desired information can be obtained without taking the drawing from the file or, if desired, any paper can be instantly removed from the file. Standard data sheets are filed by an approved numerical indexing system, and an alphabetical list is made showing the filing number of each sheet. **Engagements and anything that must be done or looked after, except routine matters, are recorded in advance in a tickler file under the date on which they require attention. The tickler file is the main basis for the temporary modification of the standard personal schedule.**

It is not supposed that the above suggestions will exactly meet the requirements of every student. Individual circumstances vary too much to allow the statement of any general rule. These suggestions should furnish a helpful starting-point from which to modify according to personal needs. The practice gained in making these modifications will be valuable. The application of the principle of Records is always difficult. If one goes too far in the development of Records, he finds the record system itself too expensive and a hindrance, in the form of red tape and paper work, instead of a help. If, on the other hand, one simplifies and cheapens his system too much, he finds that the resulting records do not give him the information when it is needed. If the student will work out his own system of Records to an efficient compromise, he will find the experience useful in business later on.

In the student's campus activity, especially after he becomes a manager, he should bear continually in mind the following questions:

Do our records give us needed information? If not, how is the fault to be remedied?

Are any of our records superfluous? If so, why not abandon them?

Do our records bring out in clear focus the information needed? If not, how may unnecessary and obscuring details be eliminated, and the essential facts be made to stand out?

If the student solves this problem for his campus activity, he will probably solve it later for his business.

The most important of all personal records is the memory. It is a system of records automatic and completely cross-indexed; and the filing clerk gives instant service. A good memory is so important that without it good personal efficiency is impossible. Chapter IV is therefore devoted to this subject exclusively.

24. Adaptation of Conditions. Adaptation of Conditions offers an immediate Efficiency Reward in the form of increased achievement.

Unadapted conditions show up by their interference with achievement. One who has never given particular attention to the matter will be surprised to find the number of such unadapted conditions to which he has become so accustomed that he accepts them without any thought and without realizing the extent to which they hinder him. Once one sets about adapting them to his needs, he will be equally surprised at the extent to which such adaptation is possible. Light, heat, ventilation, reasonable freedom from noise and disturbance, kind and quantity of food, meal hours, mastication, hours and conditions of sleep, are all conditions which are likely to prove capable of improvement. These are only a beginning. The possibilities of adaptation extend into every circumstance of one's life.

If two or more students will coöperate by timing one another, they will find the time study a valuable means of discovering their own unadapted conditions. Instructions on making time studies are given in sections 307, 308, 311–327, and 332.

Time studies are especially valuable on work which is repetitive, as much of the student's work is. For example, the time between waking in the morning and appearance at the first class is pretty much the same, day after day. A good application of time studies to this period is likely to bring an immediate Efficiency Reward in the ability to sleep later and still get everything done in time.

The time studies will also give the students valuable experience and skill in the use of this very important tool of management. This is the more important to the student in that his first job after graduation is likely to be that of a time-study man.

Of course, success must often be won against obstacles in the form of unadaptable conditions, but every such obstacle makes success the more difficult. The task of the student manager is to make success as easy for himself and for his campus activity as possible, by a thorough Adaptation of Conditions.

25. Standards. Anyone who is not already striving to attain definite Standards will increase his efficiency by doing so. The student should set for himself a definite Standard of scholarship and hold himself to its attainment.

An Ideal — for example, perfection of character — may be unattainable and yet be very valuable; but a Standard should be within the range of present practicability, otherwise it produces discouragement. A student may set for himself the Ideal of graduating *summa cum laude*. If he finds the first month that the faculty estimates his ability as a bare 70 per cent, he will do well to set his Standard for the next month at 75 per cent and see that he makes it. Having done that, he can raise his Standard for the next month by a few per cent. Perseverance in a gradual raising of his Standard may result in his attaining his coveted Ideal on Commencement Day.

Another direction in which the application of Standards will prove very valuable is in financial expenditure. Almost anyone will find that he will save money if he will classify his expenses as food, lodging, clothing, and so on, and set a definite amount to be spent for each during every week, month, and year, and then oblige himself to stay within that amount. The complete list of Standard appropriations, covering one's entire expenses, is known as his Budget. Even if the student has a large income, he will find it valuable to budget his expenses. Aside from any personal benefit, now that industry is coming more and more to operate on the budget system the prospective manager cannot begin too soon to gain at least a small-scale experience in it.

Good examples of the value of Standards in a campus activity are given by athletics. Previous records furnish Standards which the athlete strives to excel. Even when the task is to beat the opposing team, the coach has numerous Standards, such as the batting average and the number of errors, by which he judges a player's fitness for the team. If in the coaching of an athletic team such Standards were ignored, what would be

its chance of success against a team coached by a man who continually applied them?

The business manager is under an equal necessity to apply correct Standards to his organization if he is to win success against the vigorous competition which he is sure to meet.

26. Correct Methods and Instruction. Here again the student has before his eyes a wonderful example in athletics. Consider the effort expended by the coach in developing winning plays every one of which is the nearest approximation of which he is capable to the Correct Method of winning the contest. Consider also the time and practice expended by coach and players in order to put the Correct Method not merely into the conscious minds of the players but — what is far more important — into their unconscious reflexes, so that it becomes second nature to every member of the team to do his part correctly in the winning play.

No less necessary in any industrial enterprise are Correct Methods and thorough Instruction.

There is probably no operation for which it is more difficult to determine Correct Methods than for the mental work of the student. For that very reason a resolute grappling with the problem will give the student very valuable experience in the application of this principle, after which he will find the determination of Correct Methods for any industrial operation relatively easy.

The following are some of the most important elements of a correct method of study.

Be interested in the subject. You will be interested if you feel that the subject is of real value to you. The value of the subject of this book is stated in sections 1 and 2.

Develop your reasoning power. If possible take a course in logic. The study of mathematics is also very valuable to this end, and should be esteemed not only as providing the engineer with many of his most valuable mental tools but also as training for the reason. To this should be added practice in the weighing and interpretation of experimental evidence in the laboratory courses. (See also sections 190 and 191.) From the above it follows that you should insist on understanding what you study, except in so far as knowledge which is purely empirical may be accepted as such.

Insist upon classified knowledge. To this end always get down to the fundamental, or root, idea. In this subject this is the Thirteen Principles of Management, as stated in section 6, and analysis and synthesis by these principles, as stated in section 14. Master the fundamental idea thoroughly. Mentally arrange all further knowledge in its proper relation to the root idea. When knowledge is thus arranged, it becomes very much easier for the memory to retain it.

As far as possible get your knowledge out of the abstract into the definite, concrete, and practical. The engineer acquires the habit of doing this through coördinating his theory with his practical experience. The technical college realizes this, and largely uses the problem method in all its teaching, forcing practical experience upon the student from the start by devoting a large part of the curriculum to shop, laboratory, and design courses. It also at least encourages the student to acquire such experience by actual work in some form of commercial engineering during the summer vacations. It is to this end that the effort is made in this course to interest the student in applying the Principles of Management practically and immediately to the full extent of his opportunities.

By practice, gain the power to concentrate on the work in hand.

Do not attempt to do more than you can get into your personal schedule (section 17) and achieve to proper Standards (section 25).

Do your own work. Other people's exercise will not benefit you in studies any more than it does in the gymnasium.

For a fuller discussion of Correct Methods of study than it is possible to give here the student is referred to a pamphlet by G. F. Swain entitled "How to Study," published by the McGraw-Hill Book Company, and to "Learning to Study," by G. C. Brandenburg, professor of educational psychology, Purdue University, published by the university.

A Correct Method, once discovered, by continual use should be made standard practice in the form of a habit. When habits are spoken of, bad habits are usually meant, and we are cautioned to avoid them. There is too little appreciation of good habits. A habit becomes part of the subconscious personality, and one can depend upon that automaton to follow it in spite

of every adverse circumstance, unless countermanded by the conscious mind.

27. Fair Deal. There is an excellent chance to learn the Fair Deal in the give-and-take with fellow students in college life, including campus activities. The student should also make it one of the main features of his summer employment to get acquainted with the workman, to know how he feels and what he thinks, and to learn to look at industrial problems from his point of view as well as from that of the manager and owner.

28. Discipline. The first personal application of the principle of Discipline is self-control. The engineering profession has no place for the temperamental man. He who cannot, or does not, control himself is totally unfit to control others. The inflexible and unvarying laws of nature upon which his purely technical work is directly based. the temperamental man finds to be a stone wall against which he butts his head in vain. The man who controls himself in obedience to these laws finds them to be his servants.

If the college has a military department, the student is recommended to study military discipline. In its present form this is very far from being the rule of force and terror, exercised by strong-arm martinets, which one reads about and which apparently existed in the military forces of former times. Present military discipline, in its attention to the welfare and morale of those subject to it, has many lessons for industry.

The student will find a very remarkable application of Discipline in the academic institution proper, — one which well deserves his study. In our country many tens of thousands of young men and women, in the most turbulent period of their lives, are living in colleges under a very easy system of government in which the element of force is so remote as to be apparently nonexistent. In fact, they govern themselves to a very large extent. At the same time they are required by masters (whom they often consider exacting) to perform trying tasks. Under these unique conditions they not only live well-ordered lives, in the main, but the most remarkable thing about it is that they develop a most enthusiastic loyalty to the institution to whose Discipline they are subject.

The student may well give earnest thought to this extraordinary state of affairs; and if later, as an industrial manager,

he can deduce therefrom the means of inspiring in his working force a sentiment toward his corporation in any degree approaching college spirit, he will have an asset of incalculable value.

29. Efficiency Reward. Where in all the student body is the man or woman who will take a "thankless task" in campus activities? Which among the fraternities is most successful in handling its freshmen, the one which most sternly wields the paddle, or the one which rewards the efficient freshman with praise and privileges? Where is the athlete who does not prize the letter or numerals on his sweater?

The attitude suggested by these questions goes back to the very roots of human nature, and the man who is to manage his fellow beings successfully must reward those who are deserving.

The student should remember that in the case of his studies this principle is absolutely automatic. Good work in college means increased power of achievement in later life.

30. Ideals. Ideals have all the ethical meaning which is usually attached to them and also the meaning of definite purposes. Probably the most common fault of the college student is purposeless drifting. It will be well for the student to give himself an examination of conscience on the subject of Ideals. He might begin by asking himself: "Have I a definite purpose in being in college? If so, what? Is my purpose a wise one? Am I seeking to acquire Higher Common Sense, or am I trying only to have a good time and get by with a degree?"

When a student has set himself right as to his main Ideal, any number of secondary Ideals arise from it. For example, his Ideal may be to become an engineer. The next question is, What kind of engineer? When he has selected one of the main branches of the profession as his Ideal, every college course requires him further to specialize his Ideal in the selection of optional courses. Will he select these haphazard, or because they have the reputation of being easy; or will he select wisely and in accord with his main Ideal? In further analysis Ideals divide and subdivide, down to the Ideals for the current day and hour. The more nearly one can bring all his Ideals into harmony with his main Ideal, the greater will be his efficiency.

31. Personnel. The personality of a successful engineer is authoritatively analyzed in Table I on the following pages.

TABLE I. QUALITIES REQUIRED OF AN ENGINEER [1]

Primary Qualities	Comparative Value	Secondary Qualities
Character	21	Seriousness of purpose Disposition Will power Obedience Courage Loyalty Integrity Responsibility Fairness Self-reliance Reliability Self-respect Ambition Outside interests Economy
Judgment	19.5	Scientific attitude Capacity for independent thinking Common sense Reasoning power Education Experience Imagination Tolerance Open-mindedness
Efficiency	16.5	Coöperation Adaptability Control Energy Executive ability Industry Initiative Perseverance Physique { Age, Height, Weight } Resourcefulness Interest in work Aggressiveness Good habits Originality Agility Health Earning power ($___per__)

[1] The first two columns are a summary by the Carnegie Foundation (1918) of answers to a questionnaire on "Reasons for Engineering Success" from over seven thousand members of four national engineering societies. The statement of secondary qualities is drawn from less authoritative sources.

TABLE I. QUALITIES REQUIRED OF AN ENGINEER (CONTINUED)

PRIMARY QUALITIES	COMPARATIVE VALUE	SECONDARY QUALITIES
Understanding of men	15	Nationality Leadership Address Popularity Personal appearance Sense of humor Tact Sex Married or unmarried
Knowledge of fundamentals	15	Ability to learn
Technic	10	Speed Skill Accuracy Dexterity Thoroughness System Concentration Alertness Ingenuity Practicability Observation Memory Perspective Neatness Orderliness Sense faculties { --------- --------- --------- Adaptation to work of the following characteristics: ----------------- ----------------- ----------------- Comprehension of technical terminology General information Refinement and culture Linguistic ability

The statement of primary qualities quoted, in the left column, from the Carnegie Foundation is, from its origin, very authoritative. The importance of possessing these qualities is obvious to any man. It will be well worth the student's trouble to memorize this statement and make it a part of his familiar knowledge. The statement of secondary qualities is not offered as exhaustive but merely as suggestive, and may be conveniently used for reference.

Attention is called to the fact that these engineers put character in the first place, with the greatest weight. This is evidently correct, because bad character places the minus sign before every strong quality that one may possess. The importance of character is a sufficient reason for the great attention that American schools give to it.

The seven thousand engineers give to technic a weight of only ten; but it is important to remember that no engineer can be seriously deficient in the technic of his profession and expect to succeed. A similar statement applies with even greater force to those qualities which are given a greater comparative value. In other words, all the qualities are vital, and none can safely be neglected.

It is a good plan for any man to give himself an examination in these qualities at regular intervals (once a year at least) and note, for serious attention and development, any in which he finds himself lacking. It would be still more valuable for a group of men to combine, each man to grade all the rest and each man to be furnished a report of the average of the grades assigned him by all the rest. If a man knows his weak points and really wills to strengthen them, he can accomplish wonders in that direction.

32. Organization. Nature has given us a very wonderful and excellent application of Organization in our own bodies. The study of the organization of the body is recommended to anyone who is interested in management, but it is too large a subject to be taken up here. Evidently the practical application of Organization to the individual consists in his taking care of his health.

If the college has a military department, the student will find in it an example of an excellent and highly developed organization, which will repay his study.

33. Higher Common Sense. This principle requires the application to the work in hand of all knowledge, all wisdom, all science, all skill. It is certain that the best of us can, in the present state of our knowledge, make only microscopic application of this principle. A man's success, however, is determined by his relative, not his absolute, application. That is, a man who realizes that he can apply not more than one thousandth of 1 per cent of Higher Common Sense may well feel encouraged as long as he knows that he is applying more than his competitor. (See also sections 190–192, 195, 197, and 199.)

CHAPTER IV

MEMORY

34. Memory needed to supplement written records. It is impossible that any system of written records should contain all the information which the manager needs or that it should furnish instantly what it does contain. The manager must supplement by a good memory the best system of written records that ever was devised.

35. Dependence on observation and will. One may be born with a good memory or a poor one, but whatever memory one has by nature can be strengthened and developed by exercise.

As soon as one tries to exercise his memory, he discovers that it is dependent on two other faculties: the attention, or power of observation, and the will. Evidently the dependence must exist; for nothing can be remembered unless it is first observed, and while certain things may be so impressed on the mind that it is impossible to forget them, the retention and recall of the great mass of information received from the senses must evidently be dependent upon the will to remember.

36. Concentration versus alertness. At every stage of his career the engineer is obliged to practice mental concentration. The manager, however, must also be alert to receive all the information brought to him by his senses. In other words, he must be a keen observer. Much of this information is useless, but he can never tell when information of no previous value may become necessary through some unexpected event. It is useless for him to try to remember consciously all his sense percepts. The ideal condition for a manager would be to have a subconscious memory which, like a sensitized film, would retain all the impressions made upon it. Then it would be necessary only to turn back the reel in order to find the desired information. Such a condition is doubtless unattainable, but it has been approximated to a high degree in some actual cases.

As soon as one tries to practice alertness to his sense percepts, he finds that alertness and concentration are opposed mental

qualities. The designing engineer properly concentrates very intensely on the problem before him. Absorbed in a mathematical solution of a definite problem, he is apt to become almost unconscious of his surroundings. Archimedes, one of the most renowned designing engineers of antiquity, when the hostile soldier, at the sack of Syracuse, burst sword in hand into his study to kill anyone found there, did not look up from his work, but remarked, "Wait until I finish this problem." This is a striking example of the effect of interest in producing attention, — involuntary and absorbing attention in which all one's faculties become intensely focused on the matter in hand. It is hardly possible for a person ever to forget any matter in which he has been thus interested.

On the other hand, the operating engineer has every sense keyed to receive and interpret information about his machinery. He watches his gauges and meters; he listens to every sound; he feels the bearings; his sense of smell is alert to the least scent of overheated oil; and in special cases he may even use the sense of taste. Probably he could not do even a very simple problem in mental arithmetic while he is on watch. Evidently it is impossible to exercise fully both concentration and alertness at the same time, and evidently a development of either is going to impair the other. Unfortunately for the manager, he needs both in more or less degree, and the only thing for him to do is to determine what balance between them is the effective working compromise in his situation and to develop both in that balance.

37. Developing alertness. If the student finds himself lacking in alertness and power of observation he must determine, or *will*, to observe. Further, he must practice doing so. Any one of us has many occasions, as in walking the street, for example, when he has no need to carry on any conscious activity except to observe. On these occasions such a person must make a practice of calling to mind the necessity for observing and must thereupon set his mind to noting his sense percepts. With continual practice, observation will become a habit; that is, it will become subconscious.

It may be necessary to go farther back and develop the will by exercise. The will is strengthened by every act of obedience to its authority, especially if the act — such as getting up early in a cold, dark room — is one which involves some hardship.

38. Exercising the memory. As for exercising the memory itself, one will find enough opportunity for that in depending upon it as far as one dares. One dare not depend upon the memory absolutely, for even the best of memories will sometimes fail in an unexpected and inexplicable way. As for things which cannot be forgotten without serious consequences, the only safe way is to make written memoranda of them and to use one's ingenuity to devise mechanical means by which the memoranda will be brought to one's attention at the proper time. On the other hand, such mechanical means are not perfect, and need to be supplemented by the memory. For example, one might note his engagements for the day in a tickler file and then forget to look at the file. If, however, a person has developed a good memory and has also good mechanical reminders, he is reasonably safe, since it is not likely that both will fail him at once. The use of mechanical reminders impairs the memory and therefore should be limited as much as is safe. A good rule is to make no memoranda of things that can be forgotten with only trifling consequences, but, instead, to *will* to remember them.

39. Personality of the memory. The memory behaves very much as if it had a personality of its own. For example, if a subordinate had the job of reminding a superior of his engagements, and found that his superior treated all such reminders with indifference, he would soon come to do his work in a very careless way. The memory behaves in exactly the same way. **The memory requires respect and attention to its reports.** Moreover, one can apply Discipline to the memory. This story is told of a man who was in the habit of forgetting. In order to improve his memory he made it a practice, as soon as any forgotten thing came to his mind, to attend to it at once, even if he had to get up in the middle of the night and go to his office. Of course, in applying such measures one should keep within the limits set by Common Sense.

The memory, like a separate individual, is sensitive to blame and praise. Merely to reproach oneself for forgetting, or to be continually reminded by others that one's memory is poor, injures the memory. On the other hand, when the memory performs some feat of spontaneous recall, or does any other piece of good work, it strengthens the memory to dwell mentally upon the fact and to appreciate the good work done.

40. Interconnection of memories. The memory is very much aided by the interconnection of memories. The engineering designer, for example, having calculated the diameter of a shaft, will pass in review in his mind all that he knows about similar shafts, to see whether the result of his calculations seems reasonable. If it does not, he will in some way or other assure himself of its correctness before he ventures to use the shaft in an actual machine. This is the engineer's formal process of "checking," and evidently forms a temporary connection of all knowledge related to the subject.

The engineer resorts to checking in order to protect himself against error, but it is evident that the habitual use of the method is also very valuable in interconnecting the entire content of the mind and thereby strengthening the memory. If one finds that he is lacking in mental interconnection, he would do well to exercise himself in it frequently by calling to mind any object, event, or item of knowledge and then forcing his memory to recall everything that can be connected with it.

Such interconnection is like the rope by which mountain-climbers bind themselves together so that, if one starts to slip, the others hold him back. This is so valuable that one may well use artificial interconnection. For example, one may remember the order of the colors in the spectrum by the made-up word "vibgyor."

It is impossible that the manager should connect all his memories of sense percepts by voluntary interconnection. At the same time it is very important to him that when occasion arises to use any of these memories it should automatically and immediately be brought into consciousness. In order that this may be done, the manager must subconsciously make a very thorough interconnection between his different memories, so that any one will automatically recall all others that are in any way associated with it. For example, the manager of a cotton mill, when two thousand miles away from his plant, was instantly aroused to alert activity by the smell of smoke from burning cotton waste. The first whiff brought vividly into consciousness the memory of a disastrous fire in his mill. The ideal condition for the manager is that every sense percept should thus instantly recall the memories which should determine his action.

A physicist to whom the wave lengths of the different colors of the spectrum were familiar knowledge would not need any "vibgyor" by which to assign them to their proper places. His scientific knowledge would make it absurd to him to place them in any other order.

Interconnection on the basis of classified scientific knowledge is therefore especially valuable and important. If one retains by memory even a single item of knowledge so related, reason then comes to the aid of memory and rebuilds the entire structure. (See also section 26.)

Therefore the manager who has a thorough scientific knowledge of his work, on the basis of fundamental principles, has a great aid in the necessary subconscious interconnection of his sense percepts, and in their recall by memory when he needs to use them.

PROBLEMS, EXERCISES, AND TEST QUESTIONS ON CHAPTERS I TO IV

1. How can a student keep down his expenses for __ (fill in name of class of expense, as clothing, lodging, total, and so forth)?

2. Make out your personal budget.

3. What are your suggestions for securing economical use of light and heat in the university?

4. Compare the following with the statement of the Principles of Management given in this book.

The Principles of Management:
a. The systematic use of experience;
b. The economic control of effort;
c. The promotion of personal effectiveness.

L. P. Alford and A. Hamilton Church

5. Compare the following with the statement of the Principles of Management given in this book.

Economic Principles:
a. The principle of division of labor (including the separation of mental and manual labor) and the subdivision of both mental and manual labor.
b. The principle of transfer of skill.
c. The principle of transfer of thought.
d. The principle of coördination of effort.
e. The relation between unit cost and number of parts produced.
f. The systematic use of recorded experience.
g. The principles governing human relations.

D. S. Kimball

6. Compare the "Elements of Successful Operation" given in Charter Harrison's "Cost Accounting to Aid Production," pp. 132 and 133, with the statement of the Principles of Management given in this book.

7. Under each of the Principles of Management write whatever pertains to it in regard to the present condition of any industrial plant that is known to you by personal knowledge, by reading, or otherwise, and whatever action the principle suggests to you as good management under the circumstances.

8. Analyze the last season of your university in ____ (fill in name of sport) and synthesize recommendations for the next season, by the Principles of Management.

9. What is your answer to the Purdue *Exponent's* question which follows?

"Where do you find time to do it all?" is the question often asked students who always seem to have plenty of time to enter into many campus activities. Some of the students of the University seem always to get good grades, often to attend the Mixers, always to be present at athletic contests and to be connected with many commendable campus activities. This ability, to many of the less conspicuous students, seems well-nigh supernatural, yet those completing the activity never seem to have too much to do. — Purdue *Exponent*

10. Under each of the Principles of Management write whatever it suggests to you about some current event, such as a coal strike, for example.

11. Management depends upon the application of only a few principles, and the analysis of any example of high efficiency will reveal all of them in use. The plant of the Ford Motor Company is one of the best-known examples.

Referring to its Commutator Department, Arnold says, in "Ford's Methods and the Ford Shop,"

The commutator job is regarded by the Ford Shop heads as being in as nearly satisfactory condition as any department of the entire plant, and the low labor costs therein reached fully warrant the minutely detailed and profusely illustrated story here printed.

Arnold summarizes the causes of the high efficiency of the Commutator Department as follows:

How Ford makes a commutator in sixteen minutes and twenty-seven seconds of one man's time:

1. By minutely dividing labor operations. Many of the operations are the work of automatic tools. Minute division of operations is effective in labor-cost reductions in two ways: first, by making the workman extremely skillful, so that he does his part with no needless motions; and secondly, by training him to perform his unvarying operation with the least possible expenditure of will power, and hence with the least brain fatigue.

2. The work hours are short, — four hours at a stretch only, — so that workmen in good form can and do stand in their tracks, working with the regular production of an automatic machine.

3. Work slides, successive-operation men, and successive-operation tools and appliances are so placed that one man drops a piece when his part is done, either where it is ready to the next man's hand or where the gravity work slide will carry the piece to the next man's ready reach.

4. Placing the case foundry on the machine floor close to the machine tools is a very great timesaver. Not only is the rough case supply made certain, but the castings are perfectly molded and come to the finishers in best possible form, with least possible thought, travel, and labor, both of the head and the workmen.

5. All operations requiring heat, melting, annealing, hardening, and tempering are performed in furnaces so located and so grouped (where more than one heating is needful) as to save all possible time expenditure.

6. While the machine tools used are all regular commercial productions, the fixtures used with them are most elaborate, carefully designed to save movements as far as may be, and are well made, so that the workman need exercise no care or scrutiny in using them.

7. In three instances the special tools and fixtures needed are unusual: the two turret machines which produce T-671 have been so ingeniously changed as to produce more than double the work that could be turned out by ordinary handling of a turret machine.

8. Constant supervision of workmen, constant work inspection, and constant watching of tool cuts by the two tool-setters give skilled overlooking to the work of every man on the commutator job. Many of the machine hands, though not regular machinists, are highly skilled and grind and set their own tools. Every workman is perfectly aware that he is under constant observation, and that the supervisors know his work and his pace perfectly and that he will be admonished if he falls below the fast pace of the department.

9. An automatic drill chuck, the "Gronkvist," can be handled more rapidly than anything ever previously seen by me and saves much time.

10. The workmen are suitable for the performance of their operations, and for their environment and working conditions. They are docile; yet the physiologist will seek in vain for weak chins and narrow heads in the portraits of these workers, who are, without exception, mentally capable of concentration and determined effort, having well-defined, firm chins, wide jaws, and wide heads.

After reading the foregoing summary of the Ford labor-cost-reducing elements, the Commutator Department head asserted its correctness, but added as follows: "I depend largely on my tool-setters for my production. The tool-setters know exactly what I want; and as long as the tool-setters have plenty of newly sharpened tools on hand, all ready to go into the machines as soon as tools in use show loss of smooth cutting edge, I have no trouble in keeping my production up to the 1750-per-eight-hours mark. But if there is even a very small delay in replacing a cutting tool which does not work exactly right, trouble begins."

Undoubtedly this postscript is of first importance in this sixteen minutes and twenty-seven seconds' achievement.

Besides the causes stated by Arnold in the foregoing summary there are, of course, the well-known Ford high wages, bonus, and general-welfare work.

In the margin write the name of every Principle of Management, wherever its use is stated in this summary.

NOTE. The problems, exercises, and test questions given above and at the end of each subsequent chapter are intended to test the student's ability to apply the text and his experience and general knowledge. An examination composed entirely of questions like the above would be too severe. It is therefore good practice, in setting examinations, to accompany such questions by others which the student can answer directly from his knowledge of the text.

CHAPTER V

ADAPTATION OF CONDITIONS AND WORK TO EACH OTHER

41. Adaptation of Conditions and Standards. In order that correct Standards may be determined, the work and the conditions must be adapted to each other, or at least the effect of such adaptation must be foreseen in setting the standards. In order that correct standards may be attained, such adaptation must actually have been effected. For example, time studies may show a low efficiency due to a lack of any of the adaptations of conditions listed in section 61 or of others. Obviously the inefficiency can be corrected only by removing its cause; that is, by adapting the condition.

42. Standardization of conditions. Since there is usually only one best, adaptation generally results in making conditions uniform; hence, the principle of adaptation is often called the "standardization of conditions." For example, a progressive factory manager, on taking up work with a certain company, found that in the punch-press department identical machines were running at widely different speeds. The question of speeds was studied, and the best speed for every type of press was determined. Every press of the same type was then brought to the same speed.

Obviously the time required for doing any job on one of these presses was dependent on the speed of the press itself; hence, with all the presses running at different speeds, there would have been needed for every job as many standard times as there were presses. It is evident how much such a condition would have complicated the always complicated task of planning. For a press running below the proper speed, the time to do a job would evidently be longer than necessary, so that a standard time for the slow machine would not represent good performance. This further exemplifies the fact that conditions must be adapted before correct standards can be attained.

Adaptation of Conditions does not always lead to uniformity, or standardization. For example, in the same punch-press department a small amount of work was fed hot to the dies. For this work one press of each of the smaller types was fitted with a gas heater. A blind application of standardization would have led to the fitting of the same heater on every press of those types, which would have been a waste of money.

However, there is considerable value in standardization of conditions where it is applicable. A worker's speed depends upon his automaticity, and this depends upon his complete familiarity with conditions. Hence, in the frequent shifts to different work places, there will be at least a temporary loss of speed unless conditions are perfectly standardized. Other advantages of standardization are brought out in later sections.

Mention has been made in section 8 of the fact that one must sometimes adapt the work to the conditions, instead of adapting the conditions to the work.

43. Relative priority of Adaptation of Conditions. It might seem at first glance as if adaptation must be done thoroughly before any other improvements can be undertaken; but this is not the case. In section 80 it is explained that crude planning may be installed, to the considerable improvement of efficiency, in advance of Adaptation of Conditions. In section 351 it is pointed out that Instruction is the complement of Adaptation, effecting by increase of skill in the individual what is not accomplished by adaptation. In fact, every one of the other principles is capable of some application in advance of Adaptation of Conditions.

Some adaptations are very expensive, and the owners of the business may not be able to finance them before money has been saved in other directions. The routing in many American plants is not good. As the term "routing" has often been used in a sense very similar to that of "Planning," it is defined for the purpose of this discussion as the route, or path, followed by the material in moving from operation to operation through the plant. Any extensive remodeling of the routing must be very expensive, both in itself and by interfering, while it is in progress, with the regular work of the plant. The owners of a plant may well feel that they need to be helped in other ways before anything so radical can be undertaken.

All proposed improvements (and especially those involving considerable expense) should be subjected, before they are undertaken, to careful analysis by time studies and otherwise. Their probable cost should be estimated, and assurance should be obtained that they will at least repay the expense.

On the other hand, there may be unadapted conditions so bad that very little progress can be made until they are corrected. There may be others which can be corrected at small expense, with large gains in efficiency, and which are therefore among the most advantageous objects of early attention.

One of the things for investigation in connection with the selection of the point of attack (see section 480) is whether there are related to it any such unadapted conditions, and, if so, how much money can be saved by adapting them, how much the adaptation will cost, and how long it will take.

44. Principal means of obtaining data. The principal means of obtaining data on conditions which need to be adapted are

Time studies or, in the case of materials, similar analytical studies of them
Studies of routing
Scientific tests
Statements of executives
Records of unusual efficiency
Planning
Records of delays
Equipment Record, or Plant Ledger (see section 54)

The most important of these is the time study or, in the case of materials, a similar analytical study of them. In making either a time study or an analytical study of the use of any material, care should be taken to note collateral information that may be of use for other purposes than the direct one of the study itself. Such collateral information naturally contains much of value as to conditions. For example, in Table III (section 58), a time study to determine profitable division of labor, in the remarks opposite operations 1, 2, and 3 the cause of low efficiency is noted as an unadapted condition, — namely, incorrect location of the truck containing the raw materials, — and opposite operation 10 is noted the unadapted condition of poor location of the piles of material delivered from the operation. In investigating the conditions in connection with the

selection of the point of attack, it may be necessary to make some studies expressly to reveal unadapted conditions. Such study would usually be like that of Table XIV (p. 383), whose purpose is similar but more specialized.

Studies of routing (see definition in section 43, p. 37) may be made by marking lots of material conspicuously, following them through the process, and recording their movements. The conspicuous marking is to enable the observer to make full use of his time by following up a large number of lots at once. If reliable records of the movement of material in process exist, the same thing can be done more efficiently from the records, especially if one can trace the movement on drawings instead of having to walk over the plant to do it.

The power plant and other apparatus can be thoroughly investigated by means of a scientific test. The practical limit to the use of such tests is usually that of expense.

As indicated in section 460, the statements of the executives, especially the foremen, as to their troubles also contain much valuable information as to conditions.

The sources of information mentioned above are available at the outset of improvements. As Records and Planning and Despatching are developed other sources are opened.

Any cases of extraordinarily high or low efficiency as shown by the instruction cards (see section 87) the planning department should report at once to the chief of staff, and he should have them investigated promptly in order to learn the facts while those unrecorded are still fresh in the memories of the people concerned. A case of very high efficiency may have been due to the chance occurrence of some very favorable conditions. Immediate investigation may reveal them, and it may then be possible to produce them regularly and thereby to make an improvement not only of the actual but also of the standard performance. Very low efficiencies should, of course, be investigated, so that their causes may be ascertained and the unfavorable conditions be removed.

The mere effort to plan will reveal unadapted conditions as obstacles to the plans. Note should be made of these obstacles; and if it is not desirable at once to undertake their removal, they should be recorded for attention later, as recommended in section 133.

The file of exception cards to be kept in the Cost Department is explained in section 95. As fast as Planning and Despatching is installed, this becomes a complete record of all delays — except those of most trifling character — throughout the plant, together with a statement of the nature of every delay and, if possible, of its cause. At regular intervals (at least once a month) a clerk should go through this file and should summarize the money loss due to every nature and cause of delay, and should report this summary to the chief of staff.

If any nature or cause of delay is responsible for any considerable loss, the chief of staff ought to investigate, through the proper members of the staff organization, the possibility of preventing or, at least, reducing the amount of such delays in the future. If any such means are found to be feasible, he should set about putting them into effect through both the line and the staff organizations concerned.

After the card index of equipment or the Plant Ledger (see section 54) is installed, it will be found that the history of every piece of equipment will show whether it suffers from a continually recurring cause of trouble. The index will also show whether any cause of trouble affects large numbers of machines. This record is therefore the place where unadapted conditions with reference to equipment will make themselves apparent. With a view to discovering and remedying such conditions as may be of importance, routine measures should be installed in connection with the card index of equipment like those recommended above for the file of exception cards.

45. Important adaptations. The following Adaptations of Conditions are important in every plant, no matter what the nature of the business may be:

Location of plant
General cleanliness and good order
Orders in size or quantity for efficient manufacturing
Manufacture of as few varieties of product as possible
Permanence of product as to type and style
Suitability of product to equipment and of various articles of product to one another
Volume of production equal to plant capacity
Efficient equipment
Readiness of equipment for use when and where wanted

Routing (see section 56)
Accurate regulation of physical quantities involved in the process
Readiness of personnel for service when and where wanted
Division of labor
Safety of personnel
Ventilation
Lighting
Warmth
Work height
Suitable hours of work and periods of rest
Suitable materials
Clean, orderly, and properly arranged storage; standardized location of stores
Prompt and accurate inspection
Supply of material when and where wanted
Communication
Transportation
Supply of containers and tote boxes
Tool-room service
Adaptation of industrial environment to the human organism

There are other adaptations which are taken care of by the application of the other Principles of Management; and there are still other adaptations which are peculiar to every particular case.

46. Location of plant. Usually the dominant factors in the selection of a location for an industrial plant are

Location of sources of raw materials
Location of consumer's market
The labor market
Transportation

Other factors, which usually affect the selection in a less degree, are

Power
Climate
Utilization or disposal of waste products
Perishability of materials and product
Control or regulation by the government
Banking facilities
Character and price of available real estate
Building materials

In the early days of manufacturing, power would have appeared in place of transportation as one of the four dominant

factors; but the development of the electric transmission of power over long distances has given the manufacturer, in this respect, a large freedom in the selection of a site. On the other hand, a manufacturer now seeks to sell his product in a world market, and the greater distances at which he may make deliveries greatly increase the importance of transportation. Moreover, in the industrial development of the world the locations of sources of raw materials and of consumers' markets are continually shifting. Location where cheap and abundant transportation is available minimizes the effect of such shifts and therefore minimizes the risk of having to remove the plant to another location. For example, progress in sanitary science has made the tropics much more available for settlement by the white race than they ever were before, and it is probable that the near future will see a great industrial development of those regions. It is impossible now for a manufacturer to locate his plant with much reference to a tropical demand as yet nonexistent; but if his shipping platform makes contact with world transportation routes, he will be able to deliver his goods in tropical regions when the demand for them develops there.

In special cases one of the usually minor factors may become dominant. For example, control or regulation by government is usually a minor factor; but if one were considering investing a large amount of money in a brewery, this consideration would at once rule out all locations in the United States, regardless of all other considerations.

Often raw materials and the market for the finished product are widely separated. The manufacturer then has to decide which it is the more economical to ship. If the raw material largely becomes waste in process, it will usually be cheaper to ship the finished product, and the plant will then be located near the source of raw materials. Ores, for example, are usually reduced near the mines, unless very cheap transportation without serious risk of loss is available, as in the case of the transportation of iron ore on the Great Lakes. After smelting it is often profitable to ship the metal ingots long distances to places where the other conditions of manufacture are more favorable. From these places the finished products may again be shipped long distances, some of them back to the vicinity of the original

mine. An advertisement of the St. Louis Chamber of Commerce, dated 1920, reads as follows:

> St. Louis needs plants for the manufacture of small hardware, fine tools, machine tools, and tool machinery. The sale of hardware and kindred lines in St. Louis last year was approximately $102,000,000. Much of the raw material was shipped from the Mississippi Valley, manufactured in the East, and the finished product again shipped to St. Louis.

Such a condition is apt to result from the fact that the market for the product is widely distributed, while the manufacturing plant is necessarily concentrated in one location.

Raw materials, markets, and climate will usually locate an industry only within a fairly large area. Labor, power, problems of waste product, transportation, municipal or town ordinances, banking facilities, dependence on other industries, and the relative value of local markets then determine the exact town or city. All these are part of the inertia of industry.

The automobile and accessory industries of the northern middle states show several cases in which, out of a possible large area, the first plants had been started by the pioneers of the industry in their own home towns. Once the industry has started, local conditions gradually become adapted to it; and this local adaptation brings other industries of the same kind, and others allied with and dependent upon them. Such adaptation is difficult to remove or to create elsewhere, and the industry tends to become permanent in that location. The town and the goods made there acquire a reputation which has considerable selling power, and this further increases the inertia of the industry.

It remains to decide whether the site shall be urban, suburban, or rural. Questions of building materials and of character of soils and foundations come up at this time and must be dealt with according to the needs of the individual case. In any large city, near the center of population and local transportation but somewhat aside from the main retail shopping district, will be found a district full of factories. Usually these will be found to be small, many of them being in the loft class. Large American cities north of Mason and Dixon's line and east of the Mississippi River are usually ringed about, just between town and country, with industrial plants. Usually these will

be found to be of moderate size, employing several hundred or a thousand workers. On the other hand, one occasionally sees the large plant, numbering its workers by the thousands, situated in the fields, adjacent to an industrial village of its own employees. That is, we find the big plant in the country, the moderate-sized plant in the suburbs, and the small plant in the heart of the city.

The small plant is of limited financial resources, and is therefore unable to Adapt External Conditions. Consequently it is apt to seek a city site, where it is usually able to find the most favorable balance of these conditions. The principal ones of which it finds at least a fair adaptation in the city are as follows:

Freedom from large inventories, owing to the possibility of buying its materials in small quantities from local supply houses
Good transportation
Abundant labor supply
The presence of other industries on which it is dependent, such as jobbing repair shops
Easier financing
A local market for its product
Such things as are provided by the city itself, like streets, sewers, gas and water supply, and police and fire protection

On the other hand, a city site has several disadvantages. Owing to the high price of land, a small plant usually has to rent quarters in an industrial building which is often poorly adapted to its particular needs. Taxes are high, and municipal ordinances as to smoke and so forth may be very hampering. Wages are usually higher than in the country.

The very large plant is necessarily of large financial resources and is able to Adapt its External Conditions. It therefore escapes from the disadvantages of the city in the greater freedom of the country. To do this it may have to go to such lengths as building its own industrial town and there offering such inducements to residents as will attract the necessary supply of labor.

The medium-sized plant, of several hundred to a thousand or so employees, is intermediate to the other two in resources, and it therefore finds the compromise of conditions best suited to it in the intermediate location in the suburbs.

The question often arises as to whether it would be advisable to move an existing plant to a new location. The final and

decisive resultant of all the complicated considerations involved in this question is whether or not the unit cost of the product will be less or more in the new location. It is the task of the Engineering Department and the Cost Department to compare costs of production in the present site with estimated costs in the proposed new one. After Chapter VIII, "Cost Accounting" has been studied, this will be better understood. An important item in such costs in the new site is the overhead expense due to writing off a large part of the value of the old plant; for the buildings will usually have to be disposed of at a heavy loss, and it is probable that it will be cheaper to junk a large part of the equipment than to move it.

47. General cleanliness and good order. In a plant of considerable size one of the factories was conspicuous for its efficiency. The orderly state of everything connected with it also at once attracted attention, and it was as markedly superior in this respect to the rest of the plant as it was in efficiency. The superintendent of this factory had served in the United States navy, and said that he could never get over "wanting to keep things shipshape." The cleanliness of his factory, and his having a place for everything and keeping everything in its place, was not the only cause of high efficiency, for he was thoroughly versed in the technic of the difficult processes under his control and very attentive to them; but certainly neatness and good order were among the causes of that efficiency.

Order is often the condition which most and earliest requires attention. It is common to find a shop almost buried under an accumulation of junk, with a lot of dead orders lying around and with tools stored at random. To establish order it is necessary to clean up dead jobs, to scrap the junk lying around the shop, to establish standard locations of articles which are to be kept in the shop, and to establish tool rooms and tool-room service and shop stores.

48. Orders in size or quantity for efficient manufacturing.

Let $S =$ time to set up a certain machine.

Let $T =$ time to perform the operation on one unit.

Let $N =$ number of units machined at one set-up.

Then, if there is no loss of time outside of setting up,

$$\text{Efficiency of use of machine} = \frac{NT}{NT + S}$$

The relation of N to Efficiency is plotted in the curve OB of Fig. 1 for the case in which $S = T$. Evidently, in any case, as N increases, the curve continually approaches but never gets quite up to the line of 100 per cent efficiency, and reaches a point — in this case B — where the gain from further additions to the size of the order is very slow. Orders should then be run at least in the size indicated by B.

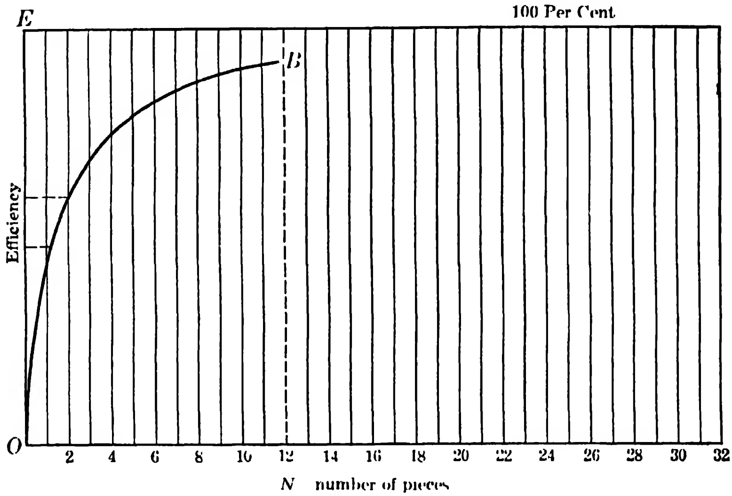


FIG. 1. Effect of size of order on efficiency

49. Manufacture of as few varieties of product as possible. In order that men may work both fast and well, and thus produce at low labor cost, it is necessary that they should specialize on a limited range of work. This applies to all grades of work, from the highest to the lowest, and in every branch of business. In order that they may specialize without losing time in idleness, it is necessary that there should be a sufficient quantity of their limited range of work to occupy all their time. Machines and tools can be designed to work better and faster, and hence at lower cost, if they are designed for only a limited range of work. The advance preparation of such machines and tools, or "tooling up," often requires the expenditure of many thousands of dollars before a single article is made. In order that this money may be recovered in the sale of the product, it is necessary that these machines and tools should turn out a large quantity.

The more thoroughly the course of production can be foreseen, the greater the benefit that can be derived from planning in advance; but thorough foresight requires a great amount of scientific study of the process, and this is prohibitively expensive, unless there is a large amount of product on which to recover the cost. Hence a large quantity of the same work makes it commercially possible to push planning to a high degree of perfection, with resulting economies.

Probably no two human feet are exactly alike. If shoes were made to individual measure, there would be as many different shapes and sizes of shoes as there are of feet. In the days when shoes were made to individual measure by the village cobbler, only the rich could afford leather shoes. Other people either wore wooden shoes or went barefoot. The present-day shoe manufacturer reduces all sizes and shapes of feet to a limited number of approximate average solutions. By so doing he assembles in each approximate average solution a sufficient quantity of shoes to manufacture by machine and thereby reduces their cost to a figure at which everybody wears them.

As with shoes, so with an unlimited range of products. The first step toward obtaining a sufficient quantity for economical production is the standardization of types and sizes in a limited number of approximate average solutions.

When this has been done, other benefits follow. Evidently it takes a smaller variety and quantity of material in stores to provide for the manufacture of a standardized product than it does for one in immense variety. The interest charged on idle capital tied up in stores and the whole cost of storekeeping are then reduced. The oftener a standard product is made, the more highly skilled the organization becomes in producing it, and therefore the lower becomes the cost of maintaining the necessary quality.

So important are the advantages of standardization that it is necessary to extend it to all the products of an industry, as in the case of screw threads; and manufacturers and engineers, through their societies, agree on standard types and sizes to apply to the whole industry. Such standardization is also the special function of the Division of Simplified Practice of the United States Department of Commerce.

When parts are made in large numbers by specialized men and machines, an obvious result is that any man or machine

does at most only a few operations, the parts passing on, to be worked on by others, and finally being assembled by still other workmen. In order that they may be assembled without excessive cost, it is evident that all parts of any one size and kind must be interchangeable. This causes the standardization of sizes to be carried to the point where the same dimension on different specimens of the same part is allowed to vary by only such "limits of tolerance" that the differences will not destroy interchangeability. Such limits of tolerance are usually only a few thousandths and sometimes only a few ten-thousandths — occasionally only a few hundred-thousandths — of an inch. Such close limits require very accurate machines and tools, jigs, fixtures, and micrometer measuring instruments. All these things are expensive, and their cost can be recovered only by the manufacture and sale of a large quantity of product.

To summarize: the cheapest production can be obtained only by manufacturing a large quantity of identical products, and such quantity can be obtained only by standardizing the product in a limited number of types and sizes.

Unfortunately, selling efficiency is opposed to the attainment of this condition. It is very much easier to sell the customer just what he wants than anything else, and it may be necessary to give him his way to a considerable extent in order to sell him anything at all.

If the Sales Department could have its way without limit, the product would be varied endlessly; but it does not pay to sell what cannot be manufactured at a profit, any more than it pays to manufacture what cannot be profitably sold. Hence, in practice, manufacturers are forced to a compromise, in which the problem is to reconcile efficiency of manufacturing with efficiency of selling.

By varying assemblies of only twenty-six letters, we get the immense variety of vocabulary of the western-European languages, and there is no limit to the possibilities of additions to them. Out of a small number of standard parts an immense variety of assembled products can be built.

There are many concerns struggling with the problem of reconciling manufacturing and selling efficiency who have never given this axiom thorough application. In order to apply it,

it is necessary to go over the product thoroughly and to reduce all the component parts to the smallest possible number of standard pieces. A stock of these standard parts must then be maintained, and the stock must be covered by a card-index perpetual inventory, or stock ledger (see section 116), which should carry maximum and minimum limits for every part. Suppose that each of three assembled articles, which we may call 1, 2, and 3, contains one of part A. Suppose that fifty of article 1 are ordered from the factory. The Planning Department should send requisitions for the parts, or worked materials, to the Stock Room, the latter should deliver them to the Assembly Department, and the Planning Department should send the Assembly Department an order for fifty of article 1.

Confining our further attention to part A, the stock clerk would credit the fifty parts on his inventory and would strike the running balance. If the stock were not drawn down near its minimum limit, he would not order any new parts; but if the minimum were approached, he would call on the Planning Department to order from the shop enough parts to bring the stock up to the maximum. If the part were used in three different articles, the number of parts ordered would average somewhat less than three times what would be made in single lots for one article.

The application of the foregoing methods is not limited to parts which are absolutely identical. Parts which differ somewhat from one another, as well as different sizes of the same part, should be designed so that they will go through as many as possible of the same operations with the same set-ups. These parts can be combined in manufacture to the increase of factory efficiency. Every part should carry on its card in the perpetual inventory, or stock ledger, a reference to the parts with which it combines in manufacture, so as to enable the stock clerk to take advantage of these combinations in ordering.

For example, returning to the illustrations used above, suppose that part A of articles 1, 2, and 3 goes through operations I, II, III, and IV. Suppose that part A′ of articles 6, 8, and 10 can be designed so as to go through operations I, II, and III with the same set-ups that are required for those operations by part A of articles 1, 2, and 3, but that it undergoes operation VII

instead of operation IV. The perpetual-inventory card of part A would bear this note: "Combine in ordering with part A′ of articles 6, 8, and 10." The card for part A′ would bear a similar reference to part A.

When the stock clerk got the supposed requisition for 50 of part A and found that its stock was drawn down low enough to justify him in ordering more, he would look for the cross reference on its card and would then see the card for part A′. Suppose he found that he had on hand 76 of part A′, and that its maximum limit was 200: he would then call on the Planning Department to order from the shop 124 of part A′, to be put through operations I, II, and III with the lot of part A ordered at the same time.

The methods described above — design in standard parts, carrying standard parts in stock, keeping perpetual inventories with maximum and minimum limits and cross references, and planning - furnish a means of reconciling a large variety of finished product and good efficiency of selling with manufacturing the minimum variety of parts in large quantities and with good factory efficiency.

50. Permanence of product as to type and style. There is hardly anything that causes more inefficiency in a factory than frequent changes of the product. Such changes throw everything into confusion, with resulting wastes, which do not need explanation.

A large proportion of such changes is needless, representing weak yielding to the whim of some customer or to the fancied necessities of a salesman, and can be stopped at once by the firm action of the General Manager and in no other way.

Of course, there must be change or there will be no progress, and there ought to be a continual search for beneficial changes. If the plant is of any size, these matters should be referred to an Experimental and Research Department to work out and standardize before they are put into the manufacture. If the recommendations of the preceding section as to design in standard parts are carried out, and changes are first thoroughly tested in a separate department, a necessary change can be localized on a few parts. with the minimum of effect on the manufacture of the article as a whole and consequently with the minimum loss of factory efficiency.

There is, of course, the type of plant which does only repair and special work. This is, in effect, a special department for all its customers, serving them by keeping the inefficiencies of special work out of their plants and taking them upon itself. Standards for such a plant must necessarily be lower than for a manufacturing plant, and its costs must be correspondingly higher. The work of such a plant may be just as profitable as that of a manufacturing plant, provided that it is able to get prices proportionate to its costs. This depends largely upon its ability to show its customers what its costs really are and that its charges are reasonable.

There are also plants which make, for personal use, articles in whose sales frequent changes of style are an immense factor. Such plants must seek efficiency by other means than permanence of product. Their profits likewise depend upon getting a proper price, which with them is largely a question of skillful advertising and salesmanship; but it is important to them to know their costs in order to know what prices to demand.

Therefore to plants of both these types good cost accounting is of extraordinary value.

51. Suitability of product to equipment and of various articles of product to one another. In the engineering industries very great attention is paid to this adaptation, but in other industries the consideration given is apt to be altogether inadequate.

The matter of suitability of product to the equipment will be brought to attention by the costs by articles which, as recommended by section 185, should be periodically reported to the General Manager. If any article is not suited to the equipment, and costs are correctly kept, the fact will be bound to show in an excess of cost of that article. Tracing back by the methods described in section 186 will show where the trouble is.

Subordinate officials are likely to know already through the more detailed records that come to them; but it may be necessary for the matter to come to the attention of the General Manager for all that, as it rests with him (or perhaps with someone even higher up) to say what the product shall be. That being decided by higher authority, the factory executives have to make it as best they can.

Suitability of various articles of product to one another is discussed in section 49, but it has many advantages besides

those brought out there. For example, in a plant manufacturing any kind of hollow ware the ability of different articles to "nest"—that is, to stow compactly inside one another—has a great effect on the efficiency of space both in storing and in shipping.

Evidently if a concern manufactures more than a very few articles, the maximum suitability of any part or article to the equipment and to the rest of the line can be obtained only by careful consideration of this very point in connection with its design. Unless the business is very small or the product consists of a very small variety of articles, adequate consideration of this matter will be impossible for people who have much else to do. Many large works employ engineers whose sole task is to effect and maintain the Adaptation of this Condition. Such adaptation is very much facilitated by having among the Records a well-classified, filed, and indexed drawing of everything regularly made. As the adaptation recommended in section 49 is effected, the drawings of any complete unit should be classified as follows:

Assembly drawing
Parts list
Detail drawings of every part

Every detail drawing of a part should be on a sheet by itself. These drawings can then be properly classified and filed, regardless of the assembly drawings. The relations of various parts and assemblies are shown by the parts lists and by cross references in card indexes or on the detail drawings. It is then easy for the engineer concerned to get together all the drawings which have to be consulted at any time in maintaining or extending the suitability of the product to the equipment and of the various articles of product to each other. Where a part is manufactured in various sizes, such references can be further facilitated and the cost of drawings reduced by maintaining only one detail drawing of the part, with the differing dimensions shown in lists on the drawing. Such a system of Records in connection with the Drafting Department of course costs something, but the cost is much more than regained in the reduction of costs of production.

52. Volume of production equal to plant capacity. The presence in a plant of definite equipment and personnel means the ability,

at maximum efficiency, to perform a certain amount of work. Fortunately, the efficiency varies only slowly as the volume of production varies on each side of the maximum point; but evidently a point must be reached where any more production means a lowering of efficiency owing to the poor workmanship and spoiled work which result from hurrying. If production falls below what will fully employ the equipment and the personnel, idleness both of workers and of machines results. The working force can, of course, be reduced; but it must then be correspondingly increased when normal production is resumed, and this deprives the employer of the efficiency due to permanent personnel.

There are two main fluctuations of volume of production. One is seasonal, and the other is a result of the general condition of business. Seasonal fluctuations are due partly to natural causes — such as inability to obtain raw materials except at certain seasons, as in the canning industry — and partly to the habits of the trade. The former fluctuation must often be accepted, at least in part; but up-to-date equipment may be able to reduce it, if not to remove it. Speaking of seasonal fluctuations, Dennison says,

> The effect of weather conditions in other trades — as in the candy trade, for instance — has been considerably helped by the refrigerating process; and other technical means can be found to avoid these other difficulties if we are only persistent enough.

Seasonal fluctuations of one market may be counteracted by cultivating another. For example, a manufacturer of motor-boat engines in the North finds his home market dead from September to March. He would naturally push sales during that season along the coasts of Florida and the Gulf of Mexico.

Fluctuations can, of course, be reduced by manufacturing to stock in dull times and selling from stock in good times, but this involves a risk of which those in business control must judge for themselves.

The risk is decreased by making, during the dull season, staple goods for which there is a permanent demand. Thus canners, whose supply of most raw materials is among the most seasonal, during the dull seasons put up articles such as pork and beans and peanut butter. The demand for men's garments

is very seasonal. Joseph and Feiss, of the Cloth Craft Shop of Cleveland, Ohio, overcome the seasonal fluctuations of demand by manufacturing staple goods to stock during the dull seasons. They find that the demand for staples can be predicted to close approximation, even to the demand for every material, size, and style. This is a most interesting example of the use of statistics for prediction.

In order to keep the factory operating at approximately 100-per-cent capacity, it is necessary to develop very close coöperation between manufacturing and selling. Above all, the selling campaign must be so Planned and the sales force so Instructed that goods may be sold at such times as the factory can produce them efficiently.

Effective coöperation of the sales force with the factory requires that the seller's market be divided into districts, that a quota of every article manufactured be assigned to every district and the salesmen therein held responsible for selling it, and that the sales force be backed by vigorous advertising. The factory, for its part, must coöperate with the sales department by keeping promises of delivery and by maintaining the quality of the product.

As to trade habits, several determined attempts to correct the seasonal fluctuations due to them have been successful. In estimating financial results of improved management in Table XVIII, p. 525, and in section 478, 5 per cent of the sales price at maximum production was deliberately set aside for the benefit of the customer. If the seller does this, or something similar, he can demand of the buyer that in order to obtain goods at the lowest price the latter shall give him such notice as will enable him to smooth out the seasonal fluctuations due to trade habits.

Morevoer, if the manufacturer, by giving the customer a share in the benefits of increased efficiency, can induce in the customer a preference for his goods, he can manufacture to stock with greater confidence.

Seasonal fluctuations in the volume of production and those due to the general condition of business may both be reduced by methods which are opposed to the manufacture of only a few varieties of product. It is the duty of the manager to decide what is the efficient working compromise in any particular

case. The shoe manufacturer makes high-cut shoes in the summer for sale the following winter. During the summer the bulk of the demand is for low cuts; therefore during the preceding winter he makes low cuts. A certain large electrical manufacturing company, during a financial depression, found it impossible to sell large power equipment, but kept running on small motors for office and domestic use — for driving fans, sewing-machines, and so on. These examples show how a judicious variety of products helps to stabilize the volume of production.

Even if the employer cannot avoid fluctuations of volume of output, he can minimize the resulting inefficiency by making his organization elastic. The skilled worker must be kept, if possible, because he can be replaced only with difficulty. The unskilled worker can be hired off the street at any time. M. W. Alexander estimates the average cost of changing an employee as shown in Table II.

TABLE II. COST OF CHANGING ONE EMPLOYEE

	New Employees						Rehired Employees
Group	Hiring	Instruction	Wear and Tear	Reduced Production	Spoiled Work	Total	
A . .	$0.50	$7.50	$10	$20	$10	$48.00	$10
B . .	.50	15.00	10	18	15	58.50	20
C .	.50	20.00	10	33	10	73.50	35
D .	.50	2.00	1	5	—	8.50	5
E . .	.50	7.50	1	20	—	29.00	10

Group A comprises highly skilled mechanics who must have practiced their trade for a number of years in order to have attained the required degree of all-round experience and proficiency.

Group B comprises mechanics of lesser skill and experience who can acquire an average degree of proficiency in a year or two.

Group C contains the large number of operatives usually known as piece workers, who, without any previous skill or experience in the particular work, can attain fair efficiency within a few months, depending somewhat on the character of the work.

Group D includes all unskilled laborers, both direct and indirect (see section 155), who can readily be replaced in the course of a few days.

Group E is composed of the clerical force in the shops and offices.

Evidently cost, as well as facility of change, requires that changes should be confined to Group D as far as possible, and then to Group E. This can be effected by recruiting according to the method outlined in section 213, and by practicing division of labor in such a way as to separate the skilled from the unskilled operations, as illustrated in Table III, section 58.

As shown in section 58 in the Standardized Operation, the stock sawyer's work can be separated into those operations which he must do himself, because they require skill, or which cannot be done by another without interfering with the sawyer, and certain unskilled operations which any strong laborer can do for him. When there is plenty of work a laborer can be employed, and he and the sawyer can work according to the Standardized Operation. When there is insufficient work the laborer can be laid off and the sawyer can do all the work.

Similar methods can be applied to many manufacturing operations, and by so doing a large amount of elasticity can be imparted to the organization. That is, it can be expanded and contracted on short notice, with minimum injury to its efficiency.

53. Efficient equipment. This is the condition against which an American plant is least likely to offend. Having plenty of equipment and having it up-to-date is a hobby of American manufacturers. In fact, the national sins are to scrap equipment while it is still valuable, thereby burdening the plant with a perpetual fixed charge for the interest on the value written off, and to have too much and too big and expensive equipment, leading to idle equipment time and excessive equipment burdens. Says Harrington Emerson, "The American plant is usually over-equipped and under-supervised." Usually the effort should be to increase the efficiency of what is already in the plant rather than to hasten to newer and better equipment.

In connection with the efficiency of equipment the excellences of electric drive are so old a story that they require nothing more than mention here. However, it is well to call attention to the fact that the choice between alternating and direct current, then among the different classes of motors of each kind, and then between single and group drives, and finally the selection of motors of capacity to give the best efficiency, presents a problem of so much complexity that it can be properly solved

only by the joint labors of two experts, one to decide what the machines need and the other to determine the motors to supply this need.

The efficiency of equipment is increased by having machines of the same type and size identical. Every workman with this group of machines is then familiar with every machine of the group. Supervision, inspection, and planning are made easier by the identity of the machines. (See also sections 172 and 247.) These facts increase the importance of a wise selection of the machine in the first instance; for this standardization, like any other, increases the difficulty of any later change to something else.

54. Readiness of equipment for use when and where wanted. In order that equipment shall be ready for use when and where it is wanted, it is necessary that the purpose for which it is to be used and its preparation for that use should be planned. This point is covered by the general application of Planning and Despatching.

Where jigs, fixtures, dies, and other small tools are used, it is necessary that there should be efficient tool-room service. In a certain large plant the punch-press department had a tool room but no tool-room service. The first result was that the efficiency of use of space in the tool vault was very low, so that the vault was apparently full though really containing much waste space. Consequently dies were stowed in the work room, under benches, and in every possible place. Because of difficulty of finding dies when they were wanted, and of the lack of advance attention to their condition, machines were delayed excessively for set-up. This decreased the capacity of the shop and resulted in congestion of its floor space with work that was waiting. This further decreased the efficiency of the department and its capacity, and thereby increased the congestion.

This is an example of the fact that inefficiencies act and react on one another, each increasing the gravity of all the rest. Conversely, if a little gain can be made in efficiency at one point, it tends to improve others as well and to make all further progress easier.

Division of labor usually requires that the care and maintenance of equipment should be intrusted not to the men who run it — who should be specialists in operating, and should not

be distracted from that — but to men having special skill in maintenance and repair work. This properly applies even to such matters as the care of belts and of small tools. Advance attention *must also be given to the condition of the equipment,* so that trouble may be prevented, instead of waiting for it to happen and then making repairs.

In Fig. 3, p. 61, are illustrated card records which give the complete history of every piece of equipment of any importance. These records furnish the data on which to base anticipative inspection, which should be organized along the following lines.

The card record of any piece of equipment will show how often it requires repairs. Usually there will be found to be a fairly definite period for every piece of equipment. The record will also show what kind of repair is most often required, and therefore what matters should have particular attention in the inspection of the machine. An inspection order is made out in duplicate for every machine. This will properly specify matters to which special attention should be paid. The duplicate inspection order is filed in a tickler file, at a safe interval ahead of the time at which the machine may next be expected to require repairs. When this file brings the order to hand, one copy is issued to an inspector attached to the Maintenance Department; and the head of the department keeps the other in a follow-up file, to make sure that the inspector's report comes in within reasonable time. The inspector makes his examination, fills out a report blank which is carried by his inspection order, and turns in his report. If it is reported that repairs will be necessary, they are made during a holiday, over a week end, or at night, when they can be done without interfering with the use of the machine for production. By this means a breakdown of the machine, with consequent loss of production, is prevented. Besides, progressive deterioration of the machine is stopped, and the cost of maintenance is reduced on the principle that "a stitch in time saves nine."

Certain difficulties are apt to occur in the installation of anticipative inspection and preventive repair. The shop executives have been accustomed to call for repairs for their equipment when they saw that they were becoming necessary. It is desirable to emphasize that they should continue to do this, and that they should not place an overdependence on the sys-

tem or wait for the Maintenance Department, in its routine inspection, to learn of the need of repairs. It seems necessary also to make it plain that the arrival of the routine time for inspection does not justify shutting down important equipment which is urgently needed for work, but that the inspection must wait for the first convenient opportunity thereafter. It is desirable also to instruct the inspectors of the Maintenance Department, when visiting a piece of equipment for the purpose of inspection, to interview the workmen and shop executives who operate it and obtain a statement of their experience with it since the last inspection. Such statement, together with such examination as may be possible during regular operation, will often make it unnecessary to shut down and disassemble.

Prevention of trouble should be carried farther back, to the routine care of equipment during its use. The following are the important elements of such routine care:[1]

Systematic, regular, adequate, and correct lubrication
Adjustment of bearings as soon as the least "chatter" can be detected
Belts tight enough so that they will not slip, and loose enough so that the bearings do not heat
The minimum possible amount of pounding of machines and their parts, and what is unavoidable done by *soft* hammers only
The use of correctly fitting solid wrenches, with the least possible use of the monkey wrench
No use of file tangs to remove tools from the spindles of machines

The auxiliary equipment of machines — for example, clamps, bolts, steady rests, and so forth — should be looked into, as it will often be found seriously depleted. In this case a reëquipment in this line is necessary to efficient operation. Such of this equipment as serves a number of machines is best located in the tool room when not in use; but articles which serve one machine alone are most conveniently located at that machine, provided means can be found to make sure that they will not be taken away by unauthorized persons. Fig. 2 shows the device adopted for this purpose on a Morton draw-bar shaper. Fig. 3 shows auxiliary equipment for a lathe, including tool box, stand for collets and instruments, portable light, and chuck crane.

[1] Reprinted from "Advanced Training-School Lecture Course," by permission of the Packard Motor Car Company, Detroit. Copyright, 1919.

55. Routing. (See the definition in section 43, p. 37.) The financial importance of good routing varies greatly. In laying out a new plant it should be given careful attention, but in an old plant the amount of money lost owing to poor routing should be at least approximately determined before expensive rearrangements are undertaken. For example, in a tannery all wet processes, such as soaking, removal of hair and flesh, and washing, were located in the basement. Between steps of the wet processes occurred the operations of splitting, pressing, and shaving, which were dry and which required better light than could be afforded in the basement. Because of the differences in conditions the latter operations were located on the floor above. This necessitated the moving of the hides several times up one floor and back again to the basement. This was evidently inefficient, but on investigation it was found to involve only a negligible loss. The reason for this was that the plant was so small that the elevator man could do all the trucking involved. As his presence was necessary for other reasons, no appreciable sum of money could be saved by improving the routing. Evidently, if the business should increase so as to require a force of truckmen, this problem would change. In general, the bigger the business, the greater the refinement that can profitably be effected in all details.

The amount of expense and trouble that is warranted to attain a good routing also depends largely upon the permanence of the enterprise. Many plants during the World War were engaged in work which was only temporary. They were adapted for distinctly other lines of work, and expected as soon as possible to return to them. Naturally the wise course for them was to make the best of such routing as they had for their temporary war work.

In connection with routing it should be understood that the money which is spent in merely moving the material about the plant adds absolutely nothing to its value and is therefore an economic waste. Nor does it add anything to the possible selling price of the product; and in so far as it exceeds the irreducible minimum, it constitutes a loss in selling in competition with a more efficient competitor. The Ideal is therefore to reduce this cost to the minimum; and this requires that the material should be moved as little as possible, — that is, that

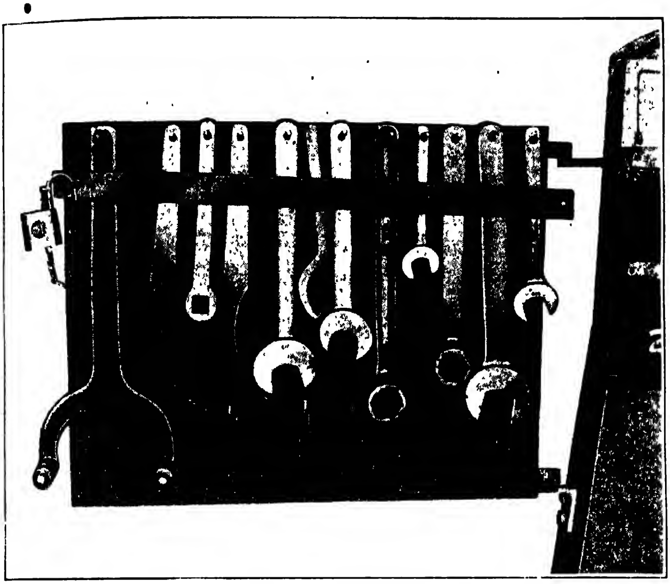


FIG. 2. Wrench board at machine

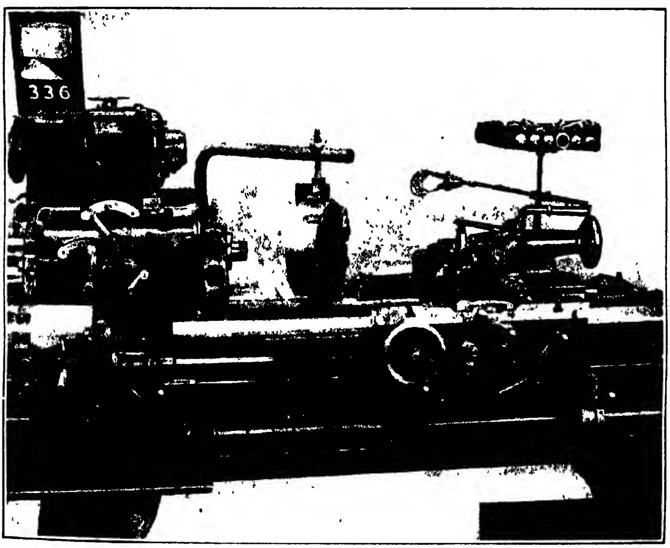


FIG. 3. Lathe with auxiliary equipment

it should go by as short a path as possible from any operation to the next, and that, as far as is practicable, the movement should be effected by cheap mechanical means instead of by human labor. Mechanical handling is facilitated by having the route definite, fixed, and repetitive.

The easiest case is that of continuous processes on only a small variety of product, as, for example, in automobile factories, sugar refineries, flour mills, steel-rail mills, packing houses, textile industries, cement mills, paper mills, wooden-box factories, and car-wheel and pipe foundries. In such industries, if they are of considerable size, excellent designs of routing are to be found. Even in continuous processes, however, a marked difference in the conditions required by two successive operations may make transportation preferable to close sequence of location, as in the case of the small tannery cited above.

The following information is necessary in order to design correct routing:

Complete list of operations in sequence
Necessary capacity at every operation in order to balance the equipment throughout
Number and size of machines necessary at every operation in order to attain the designed capacity
Floor space needed about every machine
Requirements of every machine as to drive, illumination, ventilation, and safety
Space needed for gangways, storage, inspection stations, and administrative offices

The possibility of solving the problem satisfactorily depends upon the existence of definite information on the above points. Often this is very difficult to obtain. When a problem of this kind comes up, the value of the file of instruction cards by machine numbers recommended in section 89, and of the schedules explained in sections 104 and 105, is very great. In the absence of such records or their equivalent the only way to get the information is to assemble the general knowledge contained in the memories of the shop executives, make studies of the progress of the work through the plant, and then check the information derived from each source by that derived from the others.

In a continuous process the design of the routing as a first approximation would consist in arranging the necessary machines

and clear spaces in the order of sequence of operations within the limits imposed by the building site.

On the other hand, it is always convenient to have machines that perform the same kind of work located together, in order that workmen with special skill in their operation may be kept with them. By this means flexibility of planning is obtained; for owing to the similarity of machines located together, any workman of that class can work with any machine, and any machine and any man can be used on any article. This tends also to efficiency of supervision, since a foreman or "straw boss" has to manage only closely related operations situated near one another.

The designer should not be satisfied with either a good sequence of operations or a good group arrangement of machines, but should seek the best possible combination of both. Though this will in most cases involve something of a compromise of each, it is surprising to what extent the advantages of both may often be obtained.

In assembly operations automotive engineers have worked out an excellent combination of sequential routing with specialization, or division of labor, in "progressive assembly." In this the principal element of the assembly is started from a fixed point, to follow a definite route, along which are assembling stations. At every station highly specialized workers add to the assembly only one or a very few parts. Very remarkable gains in efficiency and reductions of costs have been made by this method. It has been very highly developed by the Ford Motor Company, and many of the progressive assemblies used there are described in great detail by Arnold in "Ford Methods and the Ford Shop." The gain by this method is not only that due to sequential routing, but also that due to specialization, or division of labor.

Progressive assembly has come into use in assembly operations in other industries, and the limits to its application cannot yet be foreseen. Its possibilities should always be considered in every design of routing for assembly.

The next step in design is the modification required to meet the needs for storage, power, light, ventilation, departmental organization, safety, and sanitation, and the separation of successive operations whose respective conditions conflict, as in the case of the tannery. The flexibility of electric drive as to

location, and its noninterference with light and ventilation, indicate its convenience in designing a plant layout.

Where any considerable variety of product is made, especially in an intermittent process, the sequence of operations is apt to be so different for the different kinds of product that any arrangement of equipment on this basis must be a compromise, and often a very difficult one.

When a sequence of operations is very difficult to arrange, the advantages of group arrangement of machines as stated above lead to an almost complete abandonment of the attempt to design a sequence and to the arrangement of machines in groups according to their similarity, with usually a little general-service equipment — such as drill presses, emery wheels, and vise benches — attached to every group. In this case, efficiency of movement of materials, which will probably not be attained anyway, is deliberately sacrificed to obtain the assured efficiency to be gained from flexibility of planning, from specialization of labor, and from supervision.

Between continuous processes and completely intermittent and nonrepetitive operations, there are all degrees of importance of routing and of possibilities of perfecting it. Close to continuous processes are plants, such as shoe factories, which carry on a continuous process, but one subject to frequent change of styles and complicated by a considerable variety of product. At the other end, the extreme of intermittent processes, are jobbing metal-working shops, in which good routing is desirable but very difficult to attain on account of the lack of repetition of the processes, and which, therefore, usually employ the pure group arrangement of machines.

The design must not only provide for present conditions but also for future growth. In this the Ideal is that the whole site may ultimately be developed to its maximum capacity. In order to achieve this, the design must provide that, as future extensions and additions are made, correct routing may be preserved.

The owner of a small business is likely to rent his building, and to have to accept it as a basic condition in designing his routing; but the owner who builds his own plant should certainly base the design of it upon the design of the routing. The building itself should be considered as a piece of equipment, and should thus be designed to produce the most efficient results.

56. Accurate regulation of physical quantities involved in the process. One still finds temperature, humidity, and other such quantities left to the unaided judgment of the workman on the job. This sort of thing leads to uncertainty as to the results of processes and hence to unreliable product. The remedy is, of course, the measuring of such quantities by instruments, so that physical quantities determining processes can be controlled to standard amounts in the light of exact knowledge. The use of automatic recording instruments for this purpose has additional advantages, as stated in section 134. In many cases it is profitable to make the control as well as the measurement automatic.

57. Readiness of personnel for service when and where wanted. Concerns which have a plant physician on their staff are commonly offering to their employees free physical examination. A few concerns are even requiring their employees to take such examinations at regular intervals. The purposes of such examination are stated in section 229. In order to keep down labor turnover by preventing employees from becoming physically incapacitated, physical examination is usually followed up by advice and instruction. There is an obstacle to actual treatment by the plant physician in the employee's possible preference for some other doctor or some other school of medicine, and in the opposition by outside physicians to what they consider unfair competition. The actual treatment is therefore usually left to the employee's discretion.

Aside from such inspection and treatment this adaptation follows naturally from the application of the principles of Personnel, Organization, Fair Deal, Discipline, and Planning and Despatching, and does not require further discussion at this point.

58. Division of labor. Time studies or even casual observation in most plants will show that any skilled worker is performing not only his skilled operations but also others — such as trucking, sorting and arranging materials, lifting weights, and so on — which can just as well be done by unskilled labor. In such a case the efficiency is low because part of the work is done by higher-priced labor than is necessary.

In order to improve the efficiency it is necessary that the unskilled operations should be separated from the skilled, and

that each should be assigned to workers of the proper class. This results in division of labor. The worker on each class of operations then becomes a specialist in the narrower field and goes on to develop the higher skill due to that closer specialization, so that division of labor further increases its efficiency. (See section 300.)

In order to obtain this increase of efficiency it is often profitable to separate operations that are equally skilled, so as to obtain the benefit of closer specialization on all of them.

A striking quantitative measure of the value of specialization is given in the following agreement between the management and the workers of the Printz-Biederman Company, garment manufacturers, as to the effect of change of work on Standard time:

1. Three times standard operation for the first day, two times the second day, and one and a half the third day, when an employee is given a new operation.
2. Twice the standard time is allowed when, after ten days or more, an operator is transferred back to the former operation.

The accuracy of these allowances is reported to have been proved by tests.

On the other hand, division of labor increases the dependence of every worker on the service of others; and if this is required very irregularly, the difficulty of providing it reliably, without having some of the workers wait in idleness between times, may be so great that division of labor may be impracticable.

Confining our attention to the considerable number of operations in which division of labor is practicable, it is apparent that in every case it increases the amount of handling of the material and the monotony of the occupation. Monotony increases fatigue and thereby lowers efficiency. Hence division of labor is not without its losses; and if it is pushed too far, the losses may overbalance the gains.

In any proposed division of labor the question therefore arises as to how the operations should be divided and whether the division will pay. This question can be answered by means of a time study which, in case of minute subdivision, will have to be a time-motion study. Table III gives a time study made for this purpose in a furniture factory.

Table III. Time Study in a Furniture Factory

Order: No. 2342
Article: No. 1231
Operation: cross-cutting (stock-sawing)
Material: chestnut
- 39 per cent, sound-wormy No. 1
- 56 per cent, sound-wormy No. 2
- 5 per cent, culls
- 100 per cent

Dimensions of Lumber: 14 ft. × 9 inches (average) × 1 inch
Parts: back rails, end rails, inside rails, inside facings, center rails, center drawer fronts, back rails
Machine: cross-cut saw No. 82
Workman: No. 298, Wutt

Operation	Time in Minutes		Remarks (Time as given per Board for Main Cycle Only)
	Actual	Standard	
1. Walk to pile of boards	.066	.06	Standard assumes lumber on truck located near machine from which the sawyer can pick up board at its middle instead of dragging it endwise off the pile
2. Pick up board	.07	.036	
3. Return to saw . .	.07	.072	
4. Place board on table of saw	.011	.011	
5. Saw board	.134	.134	
6. Throw kindling off saw table into barrel	.021	.015	Kindling saved and sold as by-product
7. Handle and inspect board	.406	.406	
8. Measure board . . .	Inappreciable		
9. Assemble cross-cut pieces on table of saw	.057	.057	
10. Walk to cross-cut piles	.133	.089	Standard assumes cross-cut piles more conveniently located, as is possible
11. Place cross-cut pieces on piles	.16	.16	
12. Walk to saw from cross-cut piles	.033	.03	
Total main cycle . . .	1.161	1.07	Average total for 11 boards separately observed = 1.09

Table III. Time Study in a Furniture Factory (continued)

Orders: Nos. 364, 365, 376
Article: No. 487
Operation: cross-cutting (stock-sawing)
Material: chestnut, sound-wormy No. 1

Dimensions of Lumber: 10 ft. × 7.9 inch (average) × 1 inch
Total Linear Feet: original = 2935
Machine: cross-cut saw No. 82
Workman: No. 298, Wutt
Parts: panel and top cores

Operation	Time in Minutes		Remarks (Over-all Operation)
	Actual	Standard	
Take off apron	.4	.4	
Oil saw	.31	.31	
Dust saw table	.57	.57	
Cross-cut 85 boards			
22 @ 1.288 min., 28.31 min.			
21 @ 1.19 min., 25.00 min.			
23 @ 1.438 min., 33.08 min.			
4 @ 1.04 min., 4.16 min.			
4 @ 1.808 min., 7.23 min.			
11 @ 1.423 min., 15.65 min.			
85 @ 1.335 min., 113.46 min.	113.46	81.00	Standard (81) = .951 × 85. (.951 is estimated from study of main cycle, allowing for difference in length of boards. This allowance was based on a number of other studies of cross-cutting)
Mark pieces for benefit of later operations	.59	.59	
Read job order	.16	.16	
Talk to rip sawyer	.98	.00	
Instruction by foreman	.21	.21	
At toilet	2.69	9.249	10 per cent of total time allowed for rest
Eating	.78		
Delay by rip sawyer's getting in the way	1.23	.00	
Total — By addition of stop-watch items above	121.38	92.49	
Total — By standard watch	122.28		

By providing the cross-cut sawyer with a helper to do the unskilled work the following standards are attainable:

TABLE III (CONTINUED). STANDARDIZED OPERATION, OR CORRECT METHOD

MAIN CYCLE

Sawyer	Time in Minutes	Helper	Time in Minutes
Place board on saw table	.011	Walk to pile of boards	.06
Handle and inspect board	.406	Pick up board	.036
Measure board (inappreciable)	.000	Return to saw with board	.072
Saw board	.134	Wait for sawyer	.165
Throw kindling into barrel	.015	Place board on saw table	.011
Assemble cross-cut pieces on table of saw	.057	Walk to cross-cut piles	.089
Total	.623	Place cross-cut pieces on piles	.16
		Walk to saw from cross-cut piles	.03
		Total	.623

OVER-ALL OPERATION

Sawyer	Time in Minutes	Helper	Time in Minutes
Cross-cut 85 boards	53.00	Provide 85 boards and carry away cross-cut pieces from same	53.00
Auxiliary operations	1.67	Dust saw table	.57
Rest	6.07	Wait for sawyer	1.10
Total	60.74	Rest	6.07
		Total	60.74

The foregoing tables indicate that standard times for a cross-cut sawyer with helper can be reduced to 60.74 ÷ 92.49 = 66 per cent of standard times now set for a cross-cut sawyer working alone.

Comparison of Cross-Cut Sawyer working Alone with Cross-Cut Sawyer with Helper, based on 100 Standard Hours of Cross-Cut Sawyer working Alone

Sawyer Alone at 100 Per Cent Efficiency		Sawyer and Helper at 100 Per Cent Efficiency	
Total hours	100	Total hours	66
Wages to sawyer @ \$0.25	\$25.00	Wages to sawyer @ \$0.25	\$16.50
		Wages to helper @ \$0.185	12.21
Bonus to sawyer	4.17	Bonus to sawyer	4.70
Total wages and bonus	\$29.17	*Total wages and bonus*	\$33.41
Burden on machine:		Burden on machine:	
\$0.40 × 100	40.00	\$0.40 × 66	26.40
Burden on labor:		Burden on labor:	
\$25 × 0.65	16.25	\$28.70 × 0.65	18.66
Total cost	\$85.42	*Total cost*	\$78.47

In order to reach a decision it is necessary first to determine the proper standard time for the sawyer alone; next to determine the Correct Method, or Standardized Operation, for the stock sawyer and helper working together; and then to determine the standard time for the two working together. It can be assumed that as the general application of the Principles of Management takes effect throughout the plant, actual time on the operation will, on the average, equal the standard time. The standard times determined then furnish a basis for estimating the cost of the operations by either method of working.

It will be noticed that the total cost of wages and bonus would be increased by the proposed division of labor, but that if burdens were included the total cost would be reduced by the division. The reality of saving on the burden would probably depend on whether there was work enough to occupy both sawyer and helper to full capacity. If there were, so that output would be increased by employing the helper, the overhead would be carried by a larger volume of product, and there would be a real saving in burden. If the output could not be increased, the saving in burden would probably be fictitious. This indicates that the division of labor should be practiced if the plant were working at full capacity; that the profits of the division would decrease as volume of production fell off; and that if the plant were working at or below 66 per cent of capacity, it would be more profitable to use the sawyer without any helper.

In other words, if the plant were working sixty hours a week, at full capacity, it would pay to divide the cross-cutting operation by giving the sawyer a helper. If production should fall off to the capacity of a full crew at forty hours per week, it would be cheaper to run sixty hours and let the helper go than it would be to keep him and run forty hours, unless a material reduction of overhead expenses could be effected by working fewer hours. (See also section 52.)

In general, of course, division of labor cannot be carried far where there is either a small volume of work or a large variety of work, because it fundamentally requires a sufficient amount of repetition so that a worker's whole time can be employed in a narrow specialty.

59. Safety of employees. In the matter of minor injuries to operators a punch press without safeguards is one of the worst machines there is. The first punch-press safety devices added one or more motions to the main cycle of operations and therefore required an increase in the standard time for the job. Nevertheless, experience showed that the production record of punch presses did not fall off permanently through the addition of these early safety devices.

What is the explanation of this apparent paradox? In the days of unguarded punch presses a man would take a job as an operator and would not work long before he or a shopmate would lose a finger. A little experience of that sort of thing usually made him sick of punch-press work, and he would hunt for another job. If he was fortunate, that was the last of punch-press work for him; if not, he might come back to it under compulsion, only to leave it again as soon as he had accumulated a little money for himself or another accident had frightened him away once more.

The result was that the only permanent punch-press hands were a low class of men who from some defect -- mental, moral, or physical -- were unable to rise above that kind of work, and had the low efficiency inevitable to men of that kind. With the great decrease of danger a corresponding improvement has taken place in the quality and efficiency of the operators. The new and efficient man does the work, including the operation of the safety device, in no longer time than the old inefficient man required without that loss of time.

This is a concrete illustration of the fact, established by general experience, that it pays to afford all reasonable protection to workers. The importance of a permanent personnel, which comes up again and again in this book, is a sufficient reason for guarding against change by accident or sickness. (See section 52, Table II.)

Attention to safety is now regarded distinctly as a means of increasing production. This results not only because safety conserves labor but also because it helps to obtain its good will. Good will is recognized as a valuable asset. Too often only external good will, that of customers and the general public, is thought of. Internal good will, that of the employees, is also very valuable and important. The attitude of any concern toward the safety of its employees inevitably affects their good will. For this reason, and also because the man who is anxious about his personal safety cannot concentrate his attention on his work, it is an important element in determining the efficiency of labor.

The following are the principal causes of accidents:

Tripping and falling hazards
Handling heavy objects (overstrain etc.)
Defective structures, especially ladders, stairs, platforms, and scaffolding
Defective machinery and absence of safeguards, especially in connection with gears, pulleys, belts, shafting and clutches, and grinding wheels
Defective, especially burred, hand tools
Hazards to the eyes
Insufficient room
Uncleanly conditions
Insufficient light
Lack of good air
Unsuitable clothing
Carelessness
Bad mental condition of workmen
Ignorance
Lack of coöperation
Electric hazards

Many of the hazards listed above require attention in other connections also when any effort for gaining increased efficiency is being made; for example, insufficient room comes up for

attention in the design of the necessary clear spaces in solving the routing problem.

Bad mental condition of the workmen is to a considerable extent removed by the application of the principles of Personnel, Fair Deal, and Efficiency Reward, as will be seen by reference to the chapters on those principles. Besides this, one's mental condition is greatly influenced by the conditions under which he works, especially by warmth, by light, and by ventilation.

The first American attempts to increase safety were in the direction of safeguarding equipment. Experience soon showed that this did not reduce accidents more than about 25 per cent. It was then realized that a large part of the remaining 75 per cent was caused by various mental conditions of the workmen, generally classed together as carelessness, both voluntary and involuntary. The assumption that men's natural interest in their own safety will cause them to be sufficiently careful is not borne out by experience. Thoughtlessness, ignorance, fear of ridicule, unwillingness to take a little extra trouble, — all have to be overcome by Instruction.

In order to overcome these things, all bad mental conditions have to be removed to the extent of creating a definite interest in safety. For this purpose a campaign of safety propaganda employing all the devices of advertising and publicity is now carried on by many industrial concerns.

Closely related to protection against accident is protection against infection. This requires cleanliness, good light and ventilation, a supply of sanitary drinking water, and the prompt treatment of all wounds, no matter how slight. Other measures, such as the detection and elimination of infected persons, may be necessary under special circumstances, but these are usually taken care of by the local board of health. (See also section 57.)

All workers should be positively required to report to some designated person for first aid immediately on receiving even a scratch, in order to avoid the danger of infection. Concerns of any size commonly employ a nurse and provide a first-aid room, and find the practice profitable.

C. B. Auel, Manager of the Employee's Service Department of the Westinghouse Electric and Manufacturing Company, in

Management Engineering, lists important safety devices as follows (the words in parenthesis are added by the present writer):

Minimum labor-turnover (in order that a permanent personnel may acquire the habit of attention to safety)
Contentment } (To prevent worry and physical discomfort, the great
Good health } causes of involuntary inattention)
Cleanliness and neatness, personal and plant
Good lighting
Prohibition
Education, in the English language at least (in order that safety Instruction may be understood)
Mechanical and equivalent guards
Carefulness

It helps very much, in securing the proper mental attitude toward safety, to bring the workers themselves into the campaign. This may be done by the appointment in every shop of a Safety Committee, consisting of the foreman and a sufficient number of the workers.

Whether the latter should be appointed by the management or elected by their shopmates is a matter to be decided by the manager according to local conditions (see sections 382 and 398). The duty of every shop Safety Committee is to keep the Safety Engineer of the plant informed about conditions in its own shop.

Since safety requires adapted treatment in every plant, the manager should require his Safety Engineer to keep Records of accidents, infections, and sickness and to analyze them. They should be analyzed as to machines or equipment and as to parts of the body. This analysis will lead to the use of proper safeguards and to emphasis in the safety propaganda. They should be analyzed also as to causes of accidents, infections, and sickness. This analysis will lead to fundamental remedies.

60. Ventilation. Tests and universal experience have clearly shown that one's power falls off with fatigue. The general relation between working time and working power is shown in Fig. 39 and section 326. It goes without saying that a tired worker cannot attain a high standard of performance.

The characteristic effects of fatigue are produced by poisons deposited in the blood by the tissues broken down by work. These poisons are eliminated by oxidation in the lungs. Hence any deficiency in the supply of fresh air hastens fatigue and lowers efficiency.

The Ideal in ventilation is clean, moving air, of humidity between 60 and 70 per cent of saturation, and **fluctuating** between 65° and 70° F. This ideal degree of humidity is hardly attainable unless the weather is very damp or there is an excellent artificial system of humidifying and ventilating. If the temperature goes above 75° F. and at the same time relative humidity goes above 80, the efficiency of the workers greatly decreases.

Fortunately, window ventilation is practicable in the temperate climate during a large part of the year, and the workers themselves generally leave the windows open and get plenty of air at such seasons; but in winter the ventilation of workrooms is often inadequate. It has been abundantly demonstrated that good ventilation pays; but in the absence of artificial methods for cold weather much more than is usual can be accomplished by window ventilation. Some attention to the matter and to the direction and force of the wind will usually find a means of changing the air in a room, admitting sufficient fresh air and at the same time so diffusing it that there will be no objectionable draft. However, success is not to be expected without some Instruction of foremen and other shop executives, and of the workers themselves. It is desirable also to fit windshields at the tops and bottoms of windows to prevent drafts, and to open a number of windows a little rather than to open one wide.

In addition to ventilation for breathing purposes, machines which throw off finely divided matter, such as dust or fine grit, and processes which give off poisonous fumes, like carbon bisulphide (as in some cleaning processes), should be covered with exhaust hoods through which the objectionable matter is sucked away and discharged where it will be harmless. This practice is so general that it probably requires no further comment, and it is required by law in many states.

61. Lighting. If anyone wants a quantitative measure of the value of good illumination, let him make two time studies, one in good illumination and the other in poor illumination with all the other conditions the same. The results will be sufficiently convincing as to the value of light. The facts have been unappreciated to the extent that of 446 plants investigated, only 40.7 per cent had excellent or good lighting.[1]

[1] R. O. Eastman, Transactions of the Illuminating Engineering Society, February 10, 1920.

The Ideal in illumination is uniformly diffused light, sufficient for clear vision without eyestrain, but free from glare. The attainment of this ideal with maximum efficiency well repays the competent counsel of an illuminating expert, and it cannot be adequately treated in any other way.

Even without advice one can guard against such sins as low-hung incandescent lights, in plain bulbs, which in some places blind the eyes of the workers with an intense direct glare, and at others make any refinement of measurement or of work impossible by throwing conflicting shadows across the object of vision, from whatever angle it is viewed.

"It has also proved true that where an adequate supply of natural light is brought into service, men work more safely and cheerfully than where the best artificial light is employed. When new buildings are under construction, usually no extra expense is involved in providing sufficient window spaces."[1]

Freedom from glare, with adequate illumination by natural light, gives the preference in the Northern Hemisphere to north light from a high angle, leading naturally to saw-toothed roofs (where practicable). Ribbed glass offers the best solution of the problem on other than north exposures.

Permanence of good natural illumination requires that windows be kept clean. This means some expense, but is cheaper than to have extra work done because of the semidarkness.

Besides illumination of work places, there should be such lighting of halls, entries, and passages, especially the top and bottom of stairways, as safety requires; but only enough light for men to see their way about is needed in these places, and that is considerably less than would be required for work.

Accepted authorities on illumination give the following Standards for artificial lighting:

	Foot-Candles at the Work
Roadways and yard thoroughfares and other frequented outdoor areas	.25 to .5
Storage spaces	1 to 2
Stairways, passageways, aisles, toilets, and wash rooms	1.59 to 3
Power plant	3 to 5
Rough manufacturing, such as rough machining, rough assembling, and rough bench work	4 to 5
Rough manufacturing involving closer discrimination of detail	6

[1] N. F. A. Safety Bulletin.

	Foot-Candles at the Work
Canning and preserving	8
Medium manufacturing	9
Reading tables	10
Laboratories, tables, and apparatus	10
Work of post-office employees	10
Fine manufacturing, such as fine lathe work, pattern-making and tool-making, work on light-colored textiles; office work, such as accounting, typewriting, etc.	10 to 12
Special cases of fine work, such as watch-making, engraving, drafting, close work on dark-colored textiles, sewing	15 to 20

These Standards are higher than those in ordinary practice and tend toward the maxima given by the authorities. The reason for giving maxima Standards is that good practice is tending toward more and more intense artificial illumination. Daylight illumination in common practice much exceeds even the intensities given above.

A few tests — not enough for reliable generalization — indicate that an increase in the intensity of artificial illumination from that of ordinary practice to the Standards given above will increase production about 15 per cent, at an increase of cost equivalent to about 2 per cent of the pay roll, but with no increase of material or equipment costs or of overhead or burden (see sections 155 to 157).

The background against which the work is seen is important, as well as the intensity of illumination. The background should be darker than the work, and ideally should be a mat surface in neutral green, brown, or gray.

62. Warmth. The necessity for sufficient warmth to safeguard health and to enable workers to use their fingers efficiently is so obvious as not to require discussion. American plants as a rule are sufficiently heated except in the most extreme winter weather. Usually it does not pay to go to much expense to remedy a bad condition which occurs only seldom. It may be well to point out, in passing, that a steam power plant, exhausting into the heating system, can give both power and heat at a very low cost.

63. Work height. A worker should stand or sit upright. A stooping position soon tires him, and the stoop cramps all the vital organs contained in the chest and abdomen and produces a tendency to diseases of all those organs. All work — except

very intermittent and occasional work, which is so low that it cannot be done in an erect sitting position — should be raised, as, for example, by putting cast-iron raising bases under machine tools. If the work is high enough, the worker's chair should be adjusted so that he can sit erect, or preferably alternate at will between an erect sitting position and an erect standing position (see section 73, p. 93).

64. Suitable hours of work and periods of rest. Four thousand or more years ago the experience of employers in Babylon taught them that their workers did more in seven days by working six and resting one than they did by working every day. The institution of one day's rest in seven became so firmly embedded in Semitic industrial tradition that Moses incorporated it in the Ten Commandments and gave it the sanctity of religion.

Thanks to Moses, the Occidental industrial world received the tradition ready-made, and rests one day in seven. China never learned the lesson, and works seven days a week. It is probable that the progress of the Sabbath-keeping nations and the stagnation of the ever-working nation is more than a coincidence, — that the Chinese, by refusing to stop work one day a week and get the fatigue poisons out of their blood, destroyed their capacity for original thought and consequently for progress, just as it would become impossible to keep up steam if the stokehold were never cleared of ashes.

At the beginning of the industrial revolution resulting from the invention of labor-saving machinery, factory-owners always worked their employees for long hours, — sometimes as much as sixteen hours a day, — probably in imitation of the hours of agricultural laborers of the period. Work in factories was so much less healthful than work in the open fields that factory workers visibly deteriorated under the conditions, and the bad effects on the industrial population became so apparent that there has been a slow, reluctant, but continual reduction of the hours of work. Thus far experience has justified the reductions by increase of output instead of the dreaded reduction of output. Short periods of rest distributed through the body of working hours also increase efficiency, varying greatly according to the particular circumstances.

The greater fitness of women for operations requiring deftness, cleanliness, or delicate finger work indicates the efficiency

of employing them for the work to which they are peculiarly suited. However, the employer of women who desires to attain maximum efficiency must recognize the disabilities to which they are subject and must treat them accordingly. The proper care of women workers, and adequate heating, lighting, ventilation, and sanitation of their work places, will decrease the effects of these disabilities. Women require more rest than men; and while a man can rest on a pile of boards and in the presence of his fellows, women require comfort, quiet, and privacy for adequate rest. Progressive concerns which employ large numbers of women are realizing more and more the necessity of providing rest rooms for their special use, in many cases accompanied by the continual service of a nurse or other woman attendant. The gradual increase of installations of this kind indicates that those who have tried them find that they pay.

The whole matter has so close a relation to the determination of Standards that further discussion of it is given in the chapter on that principle, sections 326, 328, and 329.

65. Suitable materials. Some discussion of this condition is given in sections 197 and 483. It is evident that even a business of rather simple character must have a great variety of materials, and the variety and quantity of materials used by a complex manufacturing business staggers the imagination. A big business may draw a large proportion of its materials from its own sources of supply, but it would be difficult to imagine even the most simple business which could be completely independent of outside sources. To secure from any or all sources a supply of materials at all closely approximated to the needs of the business is one of the difficult problems of management.

It is impossible to make the arrival of materials from sources of supply agree in any considerable percentage of cases with the need for their use. Hence there must be provided in Organization a Stores Department, to act as a reservoir in which to equalize the inequalities of deliveries and use and to protect materials from theft, loss, and deterioration.

There must also be provided in Organization a Purchasing Department, headed by a Purchasing Agent, to buy those materials which have to be obtained from outside sources. In a large business the Purchasing Department will be a fairly

large and complex organization in itself, and will be carefully divided into a number of subdepartments.

Efficiency in buying requires the application of the principle of Personnel in the selection of a capable Purchasing Agent. The bigger and more complex the business the more important this is. Among the distinctive qualities ideally required of a Purchasing Agent are the following:

A. Natural commercial instinct
B. Business training, and knowledge of business methods and forms
C. Keen judgment of market conditions and values
D. Knowledge of the technical and practical side of the industry
E. Managerial ability, insuring such organization and operation of the department as will render the necessary service to the other departments

A, *B*, and *C* are developed by education and experience in the office and business side of the industry, while *D* is most likely to be found in a man from the engineering or manufacturing departments. It is therefore seldom that these four qualities are found in the same man. General practice seems to emphasize *A*, *B*, *C*, and *E* at the expense of *D*. Correct Organization would then supplement the Purchasing Agent's personally defective technical and practical ability by furnishing him expert advice by a competent staff (see sections 130, 258, and 267).

The amount of money paid for materials is shown by the accounts, and is therefore fully appreciated by the management. The costs occasioned by defective and unsuitable materials can be determined only approximately and with difficulty, so the natural tendency is to buy cheap materials. They may also be the cheapest in ultimate cost, but the chances are that they will not be.

The best way to guard against losses from unfit materials is to determine what qualities are needed for maximum efficiency, to express those requirements in written specifications, and to enforce the specifications by inspection. Of course, materials of minor importance would probably not repay this expense; but it is certainly warranted in the case of materials which are used in large quantities and of those which, though used in small quantities, may — like lubricating oil — have an important effect on the efficiency of the whole plant. The

preparation of specifications is a part of the determination of Standards.

Not only is the quality of raw materials important but also the quality and conditions of worked materials as the latter pass from operation to operation. Very great loss may be caused by allowing wrongly worked or damaged parts to pass along and have more work put on them before the defects are detected. At best this practice leads to excessive cost for making good the damage, and it sometimes leads to scrapping the entire article in an advanced stage of manufacture. Here again the remedy is prompt and efficient inspection.

66. Clean, orderly, and properly arranged storage; standardized location of stores. Very great losses may arise from lack of proper system in the storerooms. It may even be impossible to find materials which are actually in stock, so that duplicate materials may be bought or made unnecessarily; and even greater losses may arise from delay to the working processes.

Storerooms should be provided with shelves, bins, and the like appropriate to the nature of the goods; and these should be arranged in orderly fashion, as nearly as possible according to a natural classification of the materials.

Storerooms should be so located that materials may be conveniently and quickly issued to the shops. To the same end, they should have sufficient aisle space and should have the mechanical equipment necessary for quick and inexpensive handling of materials.

A full record of all materials in stores or expected should be kept by the perpetual inventory, or stock ledger, in loose-leaf or card-index form (of which a sample card is shown in Fig. 18, section 116). There should be a separate card for every size and every kind of material. It should be noted that this bears a record of the location of the materials in stores. Without this record it will occasionally be impossible to find material, even with the most systematic classification and orderly storage of it.

67. Prompt and accurate inspection. Reasons have been given in section 49 for manufacture within close limits of tolerance. Parts or assembled articles must also be produced in the correct number or quantity; moreover, they may have to fulfill certain physical and chemical requirements, and they have to meet whatever requirements are imposed by the trade as to finish,

appearance, and so forth. Purchased material will certainly have to fulfill some, and possibly all, of these requirements before it can safely be accepted and paid for.

The only way to make sure of obtaining these qualities is by **inspection.** As to the inspection of purchased material, it has been explained in section 65 that the Purchasing Agent is naturally under pressure to buy cheap materials, and that in order that the proper quality of materials may be secured he should be furnished with specifications. It is necessary, further, to enforce the specifications by inspection. The inspector is then in the position of judge over the conflicting requirements of dealer, purchasing agent, and manufacturing department. It is evident that he must be independent of them all. This requires correct Organization of the Inspection Department, as explained in sections 282 and 283.

As to manufactured material, or worked parts, the practice was — and in many plants still is — to have little or no inspection before the final assembly, and then to trust to the ability or inability to assemble and to the final running test to show whether or not the material is satisfactory. The result is that parts which should be scrapped in an early stage of manufacture pass on and have much more work done on them, and finally carry with them into scrap a lot of labor, equipment, and overhead cost which could have been saved if the parts had been rejected sooner. This result is intensified if the defective part has become part of an assembly. It may then be cheaper to scrap the whole assembly than to disassemble and put in a good part. If the parts will assemble at all, a lot of hand fitting is required in the Assembly Department. This not only increases the work of assembly but requires it to be done by high-priced, skilled labor, whereas the assembly of interchangeable parts in a standard manner is not a highly skilled job. Finally, this method is likely to fail to detect a defective part, which will be short-lived in use, give trouble to the customer, and result in a loss of reputation and business.

Efficient practice is therefore to inspect material, at least at all critical points, during the whole process of manufacture.

That part of the organization which directly makes the product is necessarily under pressure to produce **quantity,** and this pressure has an inevitable tendency to make it neglect

quality. It is therefore necessary that inspection should be organized so as to be entirely independent of the force which directly makes the product.

In accordance with these requirements the Inspection Department is represented in the Diagram of Organization, Fig. 36, sections 282 and 283, and in the discussion of Organization, as under no line authority below that of the General Manager. The Chain of Command runs thus: General Manager, Chief of Staff, Chief Inspector, Inspector.

It is very important to appreciate the purposes of inspection, — that although efficient inspection necessarily costs something, it is the means of preventing waste and losses which would cost very much more. This appreciation is the more necessary because many of the older managers still regard inspection as altogether a regrettable expense, to be kept down rigorously; so that the proper development of inspection is likely to devolve largely upon the younger generation.

The inspectors of work in process have three important functions: **to prevent damage**; to determine the amount of product for which the worker is entitled to credit, and which is fit to pass on to the next operation; and to maintain quality. The function of the inspector is not so much to find and reject defective work as it is **to prevent scrap from being made.** A very large part of the financial economy possible through inspection depends upon the achievement of this important function.

In order to perform this function the inspector must see the job at the beginning of work. He should see the first pieces that are produced and should give them a thorough inspection. If they pass, he should allow the process to continue. If not, he should order the operation shut down. This is one of the few cases in which it is advisable to give the staff (represented by the inspector) authority over the line (represented by the foreman), instead of making, as usual, the line authoritative and the staff advisory. If the inspector orders the operation shut down, it then becomes the duty of the foreman to correct the set-up, or whatever else may be wrong, and start the operation again. This procedure is then repeated, as many times as necessary, until the inspector finds the product satisfactory and allows the process to continue.

The inspector should also examine the last piece produced, so that if the tools have become worn outside the limits of tolerance the tool room may correct them before they are issued for another job.

The determination of the number of pieces for which the worker is to be credited involves making a record of rejections. This is discussed in section 120, under the subtopic "Watching progress and speeding lagging orders."

It is desirable that inspection should be made immediately upon the completion of the work and that the parts should pass on at once to the next operation; but this may not always be possible, and is sure not to be if the inspector requires considerable bulky or heavy equipment for the proper performance of his work. In the latter case there must be an inspection station easily accessible to the work places, and parts must be delivered there as soon as possible after the completion of work on them.

If inspection at the work place ("floor inspection") and immediately at the completion of the operation is practicable, it may be planned and despatched in the same way as the other operations. If "central inspection" has to be used and the work has to go to an inspection station, the ultimate ideal is that inspection should be planned and despatched the same as any other operation; but it is troublesome to get this going, and the installation of departmental planning and despatching should not wait for it.

In order to get departmental planning and despatching going, the planning subprinciple of the Reservoir (see section 120, "Getting assemblies ready") may be applied to the inspection station. The departmental planning then takes up the work every time the inspection station finishes with it, planning it on to the next "central inspection," at which point the departmental planner drops it from his plans until it again emerges from the inspection station. Even at the outset the departmental planners should indicate to the inspection station the order in which work is wanted from it and, as soon as planning is sufficiently advanced, the time when delivery is wanted. As long as the matter is being handled in this way, the central planning office must leave corresponding discretion to the departmental planners.

In some cases every piece must be inspected if bad work is to be prevented from passing on. The problem of inspection is then very difficult. If the work will bear the cost, a sufficient inspection force may be provided to examine every piece. Otherwise about the only suggestion of general character that can be made is that workers may be offered a small bonus for discovering and rejecting faulty pieces that come to them. The inspection then becomes a by-product of the direct work of people who have to handle every piece. If this plan is followed, the rejections by direct workers should usually be passed upon by an inspector, and the latter's approval should be necessary to make the rejection valid. The inspector should then make out the record of rejection, for which see section 120, "Watching progress and speeding lagging orders."

The inspector compares the material with Standards and accepts or rejects accordingly. The preparation of the Standards is usually the work of the Engineering Department. Absolute accuracy is impossible. The best that can be done is to bring error within permissible limits. Therefore it is necessary to state to the inspector not only the absolute Standard but to what extent the actual work may depart from it without its being necessary for him to reject it. As to dimensions this procedure is standardized by showing limits of tolerance on the drawings. It is important to remember that the higher the degree of excellence represented by the absolute Standard, and the closer the approximation to it required in the actual product, the greater will be the cost. Therefore the engineer should not make either more severe than is necessary to fit the product for its intended purpose.

In occasional cases, providing the inspector with definite Instructions and limit gauges will enable inspection to be done by unskilled labor; but in many cases it is impossible to carry this out to such a degree of perfection as to do away with the need of excellent judgment on the part of the inspector. An incompetent inspector always tries to protect himself by making his inspection very severe. Such a man will cost more by unnecessary rejections than will a man of proper grade.

Inspection does not proceed satisfactorily, either, unless the inspectors have the Ideals of helping the line, or direct, organization and keeping down costs.

Finally, the manager must not overdo inspection. Inspecting too much or too often or with too great severity will amply justify the objections to it as an unnecessary expense. The design of an efficient inspection system is an important and highly skilled operation, and must be carried out to suit the case in hand. To be efficient, inspection must be sufficient to perform the three functions stated above, and **no more.**

68. Supply of material when and where wanted. Where the problem of routing has been very well solved, so that operations are located in their proper sequence, and successive operations are located near one another, the workers may simply hand the materials along from one to another. A very small trucking force may move the work, as it is completed, from the last operation of one department to the first operation of the next.

Where large amounts of material are handled in this way, it has been found profitable to provide smooth rails, or ways, along which material can be pushed, with a minimum of labor, to the next operation. In some cases this labor can be further reduced by providing smooth slides, inclined at slightly more than the angle of friction of the material. By raising the material very slightly above the working level, the delivering operator places it in the upper end of the slide, whence it is carried by gravity to the person who receives it. This method is, of course, limited to materials of which the units are neither very heavy nor easily injured. In extreme cases, and those in which the time of every operation has been very closely determined, the materials may be moved past successive operators on some form of power-driven conveyor, every operator doing his own work as the material passes him (see section 70). In intermediate cases the material may be set on a runway in which rollers are mounted. Each worker then easily shoves the material along the runway to the next operator. This is especially convenient if the operations are such that they can be performed without removing the work from the runway. A slight downward pitch of the runway in the direction of travel will often make the movement still easier.

In any case there is the possibility of considerable laborsaving in the movement of material by up-to-date equipment. Attention is called to those forms of trucks which permit of

unloading in mass, without disturbing the load and without the necessity for handling the units of the load in detail.

Where the routing is less perfect, the movement of material must receive the attention of the planning department; and in any case this must be given to the initial movement of materials from the storerooms to workrooms, and to the movement of dies, jigs, fixtures, and other tools from tool rooms to machines and back again. These matters are discussed in the chapter on Planning and Despatching, sections 97 and 98, except the movement of material from operation to operation. Here the despatch board gives advance notice of what is wanted, and the move-man may either consult the despatch board directly or, if that is not advisable, the despatcher can consult the board and make out the necessary move orders.

An intermediate case occurs where the movement is too complicated to be reduced to a simple flow from operator to operator, but still is so simple that the move-man can readily learn it by rote. All that is necessary then is for the move-man to learn the routing, and move the materials finished at one operation immediately on to the next.

It has been found that direct workers lose a great deal of time if the work comes to them in an unadapted condition, as when a man has to pick out successive pieces of work from a tangled or disorderly pile, or where parts which have to go to a machine in a certain way are received hit or miss by the operator, so that he has to turn them over or around before entering them in the machine; and that the direct workers also lose a great deal of time if they have to hunt around for a place to deposit their finished pieces. Sometimes automatic arranging, or sorting, machines may be used to adapt the condition in which the work goes to the operator; and in the Ford plant the work slides enable many operators to drop their finished work from the hand at a standard point, without any thought. If these methods are not practicable, division of labor can often be applied, at least to adapting the condition of the work as received. The work of adaptation can then be separated from the main operation, and the former may be assigned to cheaper workers, one of whom can probably serve several operators.

69. Communication. In order that operation may be efficient it is necessary that Organization should produce teamwork.

This is impossible without mutual understanding among its members, and understanding is based on communication. It is therefore necessary that Conditions should be so Adapted as to facilitate communication.

In an industrial plant the principal means to this end are the plant mail and the telephone. The former is usually in a satisfactory state, but there seems not to be an equal appreciation of the telephone. Every plant official down to the grade of foreman, and in special cases down to that of assistant foreman, should have a desk telephone. A planning office of any size should have several, and every shop shipping clerk and receiving clerk should have one. A shop despatcher is usually conveniently located for using the foreman's telephone; if not, he should have one on his own desk. A plant employing more than two or three hundred men ought to have the internal telephones connected by a private exchange, and the service should be excellent. Anyone who has experienced the convenience of automatic service in such a private exchange would prefer it to the delays and errors of a manual exchange.

70. Transportation. Transportation within an industrial plant may be classified as intershop and intrashop. In connection with intrashop transportation the relation between the planning staff and the move-gang is important, and is taken up in sections 52, 97, and 98. As to intershop transportation, in a large plant it should be organized as a separate department under its own head, who should report directly to the Factory Manager (see Organization Diagram, Fig. 36, p. 227). Its work should be planned and despatched as to details by its own departmental office.

The question of equipment for the internal transportation of the industrial plant is a big and important one, and in recent years it has become a recognized specialty in the engineering profession. It is possible to give only a brief summary here. For intershop transportation the standard-gauge plant railway is standard; the locomotive crane is a tool of all-round usefulness; while the automobile truck, with its various auxiliary appliances for hoisting and for quick loading and unloading, is the main reliance for nonrail transportation.

Intrashop transportation is now in a transitional stage, owing to the great advance in recent years in machinery for

handling materials. It is being especially affected by the development of conveyors. In continuous processes conveyors **cut out waste time** through forcing, and at the same time making possible, the utmost refinement of Planning and Despatching and of plant layout, or routing. This speeds up production, increases the rate of turnover of capital, cuts down Work in Process account, saves floor space and cuts down the Rent account, and reduces the cost of trucking and handling (see also section 68).

Wherever it is possible to move materials downward, gravity can be used to do the work. Some very thorough designs of this kind are in use, especially in mail-order houses. In these, incoming goods are elevated to the top floor and thence are moved by gravity only until they arrive at the loading platforms for shipment. The materials are moved on gravity roller conveyors, gravity roller spirals and spiral chutes, or friction spirals.

> Gravity, the greatest of nature's latent forces, is available in every modern industrial operation. This free power, ever ready for useful work, has never been more economically used than through the application of gravity roller conveyors to the handling of commodities. . . . Continuous improvement in design and workmanship has made it possible to convey packages at surprisingly low grades, with correspondingly long horizontal runs.[1]

In intermittent industries, owing to the lack of an absolutely fixed routing of materials, the field does not look promising for the use of conveyors within shops. Here the overhead traveling crane is standard for heavy articles and, of course, can handle articles which are beyond the capacity of any existing conveyor. The elevating truck (propelled by storage batteries for long hauls) is standard for lighter loads. Even in intermittent industries portable conveyors may make savings in handling costs in yards and storerooms. These conveyors are very flexible and adaptable and can be fitted to almost any case of handling materials.

Conveyors are made in a large variety of types, and it is essential to their successful use that a type and size suitable to the purpose should be selected.

[1] R. V. Wright, Material-Handling Cyclopedia. The Simmons-Boardman Publishing Co., New York City.

Closely connected with transportation are the problems of locating responsibility for goods in movement, of preserving their identity, and of securing proper sorting of materials for convenient handling by the receiving shop. The Plant-Delivery Tag (section 97) and the Route Tag (section 98) are at once the clerical means of addressing articles, of locating responsibility, and of preserving identity. The latter is no small problem when hundreds of small valves, for example, are in work which are too nearly alike for identification by casual inspection but which are not interchangeable.

The principal trouble with tags is their liability to become detached, especially from castings and forgings. For these parts a satisfactory means of identification is to have a symbol painted on with black or colored shellac by the shop which originally produces them, except when they have to pass through heat treatment. Then it will probably be necessary to require the parts to be looked over just before they go into heat treatment, to require identification tags to be provided for all parts from which they are missing, to require all tags to be removed and kept during the heat treatment, and finally to require all parts to be re-identified and to have their tags again placed on them immediately after the process. Special memoranda or sketches are sometimes necessary on the tags to make sure of correct re-identification. All this is some trouble; but anyone who has experienced the troubles due to loss of identity of steel castings, in and after annealing, in a plant which handles large numbers of them will realize that the care necessary to prevent trouble is the lesser of two evils.

71. Supply of containers and tote boxes. It devolves upon the delivery shop to send its product out properly sorted. If it is insufficiently supplied with containers, its shipping force will get its output into what containers it has, with resulting mixture of orders and confusion in the receiving shop. In order to make sure of a sufficient supply of containers it is convenient to establish a central place for their storage, manufacture, and repair. All foremen then clean out of their shops all skids for elevating trucks, containers, and tote boxes for which they have no use in sight, and send them by plant transportation to this central point. They are there looked over, repaired as necessary, inventoried, and stored. Foremen needing these articles

draw them by requisition on this central storage. The storekeeper at this central point is responsible for maintaining a sufficient supply of these articles.

72. Tool-room service. Tool-issue rooms, or "tool cribs," are for the purpose of taking care of tools, of issuing them to shop workmen with the greatest practicable despatch, and of keeping Records of the men to whom tools are lent. In large shops each department usually has a tool-issue room; and in such instances it is a good plan to have a central tool storeroom in which reserve stocks of standard tools may be kept, to be supplied to the issue rooms as required. The tool-supply system should be organized to render the best possible service to the plant, and as a means of attaining this end the tool storeroom and all issue rooms should be placed under the authority of one foreman responsible to the superintendent for their management. The tool foreman should turn over all routine work to subordinates, so that his time may be largely occupied by supervising the force and attending to the more important matters that arise. Every man in charge of a section of the tool-supply system should be held strictly accountable for the condition of tools or records under his care and for the quality of service rendered by his section.

The equipment of the tool storeroom and tool-issue rooms is primarily for stowing tools in the most accessible manner. Open shelves should be used whenever possible, bins and pockets when these are necessary to prevent the stock from rolling upon the floor, and drawers only as a last resort, because they hamper inspection and encourage careless stowing. Revolving racks and other special equipment should be used whenever they facilitate stowing or handling. Fig. 4 shows a tool-issue room in which the tools are well stored. However, it would be easier to inspect the tools if cutting ends, points, or edges in all cases pointed into the room. Note that the room is painted white, to increase visibility and diminish eye fatigue. The stock on hand of each particular tool should be large enough to meet all reasonable demands of the shop, but at the same time care should be taken to avoid overstocking with tools of any kind or size infrequently used.

Every issue room or section of the tool storeroom should be under the charge of a supervisor responsible to the tool fore-

man for the condition of tools under his care. This supervisor should frequently inspect all tools ready for immediate use and should dispose at once of damaged or partly worn tools that may get into the racks. He should also see that tools and receipt checks are in their proper places. So far as possible, tools should be stored according to their class; for example, all lathe and planer tools should be placed in one section, taps and dies in

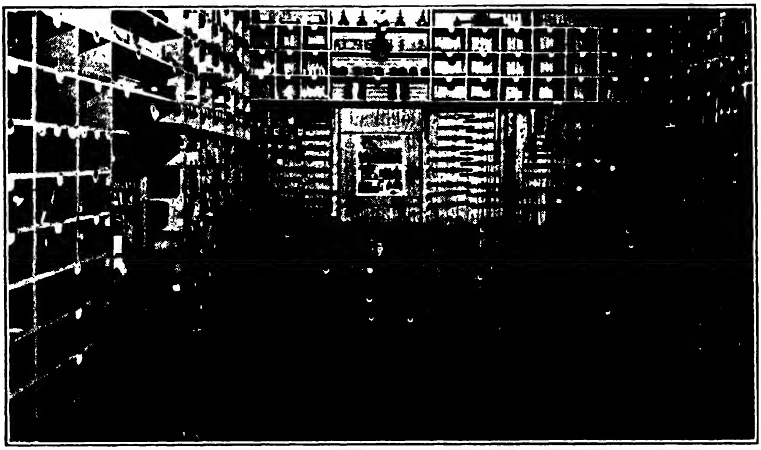


FIG. 4. Tool-issue room

another, and milling cutters and slitting saws in a third. Odd-sized tools should be kept with standard tools of the same kind, but special tools should be kept in an entirely different section.

The Records of loans of tools to workmen are a common source of trouble in shops. This condition arises from the fact that, as the work in the tool-issue rooms is necessarily intermittent, it is desirable that the men who issue tools should keep the records in connection with their other work, in order to fill their time and save the wages of a clerk in the issue room. These men have to know the tools and understand the proper care of them, and this leads to the selection of shop men for the purpose. Such men are very seldom good clerks and, in fact, seem to have a constitutional aversion to clerical work. The records therefore have to be simple, and writing has to be avoided as much as possible.

The method commonly used is to give every worker several brass checks. These checks all bear a number by which he is known in the tool-room. When he draws a tool he turns in a check, and the tool-keeper hangs the check in the place of the tool drawn. The trouble with this system occurs when a man leaves. It is customary to require him to turn in all tools belonging to the employer before he receives the balance of pay due him. In this system it requires a complete search of the tool-issue room to determine what tools he has out. This involves so much trouble that it is seldom done thoroughly. The result is that the man gets his tool clearance without actually turning in all his tools. With the usual large labor turnover this easily amounts to a large loss.

To avoid this trouble, it is necessary to use the double-check system. In this, in addition to brass checks for the men, every tool has a brass check. To make the system really complete every such check must bear the designating symbol of the tool to which it corresponds. In the tool-issue room there is a board which bears the tool-issue numbers of the men in the shop. When a man draws a tool, the tool-keeper handles the man's check the same as in the other system. He also hangs the check which designates the tool issued on the hook at the man's number on the board. The checks at the man's number always show what tools he has out.

All precision instruments, such as micrometers, gauges, straightedges, and vernier calipers, should be returned to the tool-issue rooms at the close of each working shift. These instruments, when returned, should be kept separate from other tools; and before they are placed in racks for reissuing, all scratches and other blemishes should be removed and the instruments should be compared with working standards. The working standards should never be issued for use in the shop, and should never be handled by anyone except the supervisor of the tool-issue room and whatever skilled man may have the duty of checking shop precision instruments by the working standards.

73. Adaptation of industrial environment to human organism. The human organism has an immense capacity for adapting itself to its environment. In the earlier days of factory industry, reliance was placed upon this almost exclusively, and

almost no effort was made to adapt the industrial environment to the workers. We are now beginning to realize that it is just as absurd to expect the human producers to give their maximum output under adverse conditions as it would be to expect a steam engine to operate at maximum efficiency if the cylinder walls were bare to the outer air. In other words, our interest in this Adaptation is not a matter of humanity only — though that should be sufficient — but we are interested in it also as a matter of production (see sections 327 and 328).

Our work in this adaptation — in fact, our apprehension of it — is just beginning, and it runs into infinite detail, requiring the expert knowledge of the physician, the physiologist, the psychologist, and the anatomist rather than that of the engineer. However, the industrial engineer should appreciate the possibilities for improvement, and for some time to come it will probably devolve upon him to be the prime mover of intelligent activity in this direction.

The elements of this adaptation may be divided into two classes:

1. Elimination of unnecessary fatigue
2. Arousing interest in the work

The heart works for a brief interval and then rests long enough for complete recuperation. It is hardly reasonable to expect the work of industry to be done that way. Probably the most efficient result is attained by allowing some accumulation of fatigue during working hours, to be removed during the hours off work, especially during sleep. The probability is, however, that this method has been carried altogether too far. Actual tests have shown an increase of production through the use of rest periods during working hours, in a sufficient number and variety of cases to warrant the assumption that a much more general use of rest periods might be profitable (see section 64).

Rest is the cure of fatigue. The other side of the matter is the prevention of fatigue. It is clear that to whatever extent an industrial operative becomes fatigued from causes other than the work itself, to just that extent his power to produce is drained off and wasted. In other words, unnecessary fatigue of the workers reduces production in exactly the same way as preventable friction of the machinery.

One measure which will greatly reduce fatigue is possible at once and at small expense. That is the seating of workers in all cases where it is possible for them to work efficiently in a sitting posture. As an immediate measure, while correct seating is being worked out, the use of any kind of seat is better than to work standing.

A correct seat should be adapted to the person who sits in it. It is not commercially practicable to accomplish this perfectly; but by providing seats (even of inexpensive construction and

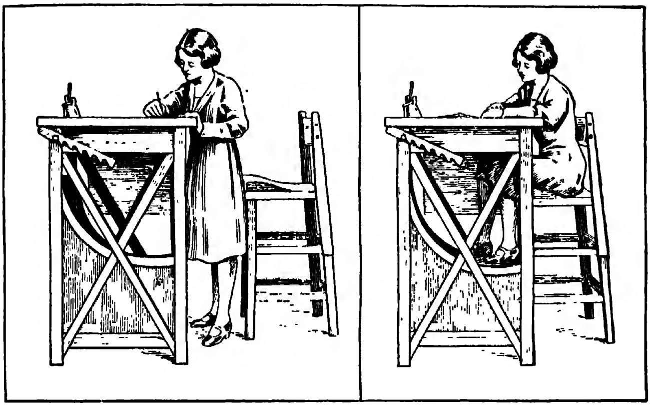


FIG. 5. A sitting-standing stool and cylindrical foot rest

material) which are adjustable as to the main elements of height and of position of the back rest, as shown in Fig. 6, a reasonable approximation may be obtained.

Unless the worker can place his feet comfortably on the floor, a foot rest should be provided. An ideal foot rest is a cylinder — concave toward the worker's knees, as shown in Fig. 5 — of which the axis is the line of the worker's knees, so that the feet rest comfortably on any part of the cylindrical surface. On account of cost a flat, adjustable foot rest as shown in Fig. 6 is more likely to be provided.

Unless the worker can get his legs well under the bench, as shown in the seated position in Fig. 5, he is forced into a stooping position which is unnatural, uncomfortable, and fatiguing. Benches, desks, and tables should therefore be free from ob-

structions which prevent the worker from assuming a correct sitting posture.

If possible, the seat and bench should be so arranged that the worker can either sit or stand (see Figs. 5 and 6). The ability to sit or stand at will, as the worker becomes tired in either position, greatly reduces fatigue. It is important that the worker's elbows should be at the same height in both positions. The fingers should be from one to three inches lower than the elbow.

Personal experience has probably convinced all of us of the comfort of a good back rest on a seat, and the authorities on

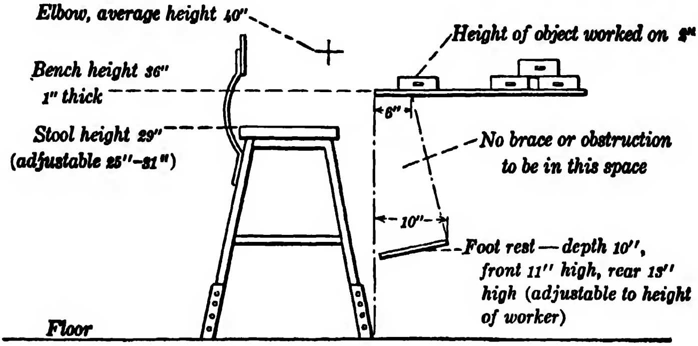
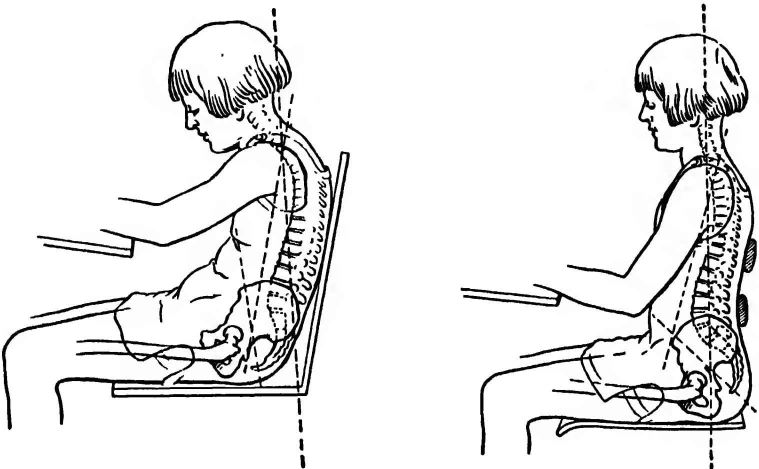


FIG. 6. Principle of sitting-standing stool

industrial seating are practically unanimous in recommending back rests. As shown by Fig. 7 *a*,[1] the backbone is a flexible column, free at the top and fixed at the bottom by articulation to the pelvis, and eccentrically loaded with the weight of the head and shoulders. Against the curvature produced by this load, nature has strengthened it by giving it the opposite deflection in the lumbar curve of the small of the back. Reference to Fig. 7 *a* shows that when the ordinary back rest is used, the resultant of the downward pressure of the weight of the head and shoulders and of the pressure of the back rest against the spine at or slightly below the shoulders is a downward thrust in the direction assumed by the spine in the figure. One naturally slumps into that position in order to ease the spine by bringing it into line with this resultant; but this position reverses the

[1] Fig. 7 is used by courtesy of the Domore Chair Company, of Elkhart, Indiana.

lumbar curve, cramps all the vital organs of the chest and abdomen, and concentrates pressure at and near the base of the spine. This position therefore soon becomes unbearably uncomfortable, and one seeks relief by sitting bolt upright, away from the ordinary back rest. It is evident that the proper place for a back rest is where it strengthens nature's reënforcement of the spinal column against the deflection due to the load; that is, in the small of the back, as shown in Fig. 7 *b*.



a *b*

FIG. 7. Incorrect and correct back rests

The following adaptations may be listed under the elimination of fatigue, though they are important in other connections also: Clean up work places, keep them in good order, and avoid crowding. Suppress distractions, of which the greatest is bodily discomfort. Suppress distracting noises as much as possible. We have so much noise in industry, that most of us accept it as inevitable. Perfect silence is unattainable and probably undesirable, but a great deal of industrial noise is preventable. In health most of us can work without being conscious of distraction by noise, but doing so requires an unconscious effort which might better be expended in useful work.

The development of machine processes has tended to take from the worker both manual skill and creative ability. The result has been to make his work monotonous, to dull his in-

terest in it, and cause him to regard it as mere drudgery. This tendency is increased where the work is closely studied by an engineer and reduced to a standardized repetitive operation. These are not reasons why we should abandon either machinery or efficient management. There is rarely a great gain without some loss. The thing to do is to find other means to compensate for the loss, — in this case to make the work more interesting.

This again is a work of humanity, but also sound commercial engineering for the benefit of production. The effect of fatigue in diminishing production has been stated above. The man who is interested in his work resists fatigue because of his interest. Furthermore, the drudge whose work is monotonous and distasteful becomes irritable, and his mind is a fertile soil for all sorts of discontent and false economic and social doctrines. It is probable that the lack of interest of present-day industrial workers in their jobs is one of the principal causes of large labor turnover and industrial unrest.

It must be admitted that the remedy for this condition has not yet been discovered. It is hoped that it will be found along the following lines.

For reasons which are stated in sections 421–423 it is good practice to give each *worker* some diversity of occupation, no matter how much *operations* may be subdivided. This is a beginning of relief from monotony.

There is a small amount of experimental evidence to the effect that efficiency is increased by having a worker stay with the material through a series of operations long enough to give him some idea of what it is all about. The theory of this is that one is not interested in work that seems to him to be purposeless, or whose purpose is not apparent to him, and that by taking the material through a sufficiently long series of operations the worker comes to understand the object of his work.

There is hardly any job that does not offer at least some opportunity for thought and some chance of development of skill and improvement of performance. If, now, by Instruction, the workers are taught to understand their jobs and their possibilities (see sections 234 and 432); if, through systematized Efficiency Reward, they realize an immediate personal gain from improved performance; if their suggestions are sought and

rewarded, and if a regular path of promotion opens to them hope for the future as a reward for personal efficiency, then it is to be hoped that they will find their jobs interesting, and will find joy in their performance. It is hoped, further, that as our knowledge of the principle of Personnel increases, workers will be more often assigned to the jobs for which they are best suited, and that their natural fitness will tend to make them interested and happy.

74. Peculiar conditions. Besides the general conditions which are listed above, every industry, every plant, every department, and every operation has peculiar conditions of its own. The means of investigating these conditions are the same as those stated in section 44 for the investigation of conditions in general.

75. Minor conditions. In connection with operations there are many minor unadapted conditions which in the aggregate cause a heavy loss. For example, see Table III, section 58, Remarks column, opposite operations 1, 2, 3, and 10. It is safe to say that if the sawyer were put on Standard Time for the operation and received an Efficiency Reward for approximating the standard, he would himself adapt the conditions there noted. It is important that the workers should be used in this way to adapt minor conditions, by installing Standards and starting Efficiency Reward as soon as possible. (However, see section 453 as to the proper time to start Efficiency Reward.) Experience has shown that the direct workers themselves will very seldom accomplish thorough Adaptation. Therefore the management should give attention to these minor conditions as soon as more important matters are out of the way.

76. Adaptation a means of progress. About twenty-eight years ago a technical paper was published in which the author bemoaned *standardization* as the death knell of progress. As we look back his fears seem somewhat amusing. If a concern had a monopoly, it might achieve standardization, allow it to degenerate into stagnation, and refuse to make further progress. Sometimes a concern does that, whereupon ossification sets in, and in due time the remains are buried. Meanwhile the world of industry moves on, making of *Adaptation* not an obstacle to progress but an instrument of it.

BIBLIOGRAPHY

ARNOLD, Ford Methods and the Ford Shops. Engineering Magazine Company.

COES, H. V. "The Rehabilitation of Existing Plants," *The Engineering Magazine*, July, 1915.

DUTTON, H. P. Factory Management. The Macmillan Company.

KIMBALL, D. S. The Principles of Industrial Organization. McGraw-Hill Book Company.

KURLANDER, J. H. *Lighting Data Bulletin 106A*. The General Electric Company.

LANGE, H. B. *Journal of the American Society of Mechanical Engineers.*

SHEPARD, G. H. The Application of Efficiency Principles. The Engineering Magazine Company.

SHEPARD, G. H. "Tool Supply and Stock-Carrying Methods," *Machinery.* The Industrial Press.

STICKNEY, G. H. Lighting Legislation. The General Electric Company.

TIPPER, H. Human Factors in Industry. The Ronald Press Company.

Eyesight Conservation Bulletin I. Eyesight Conservation Council of America.

Industrial Lighting Code. Industrial lighting codes of the following states: California, New Jersey, New York, Ohio, Oregon, Pennsylvania, and Wisconsin. Illuminating Engineering Society.

Waste in Industry. Committee of the Federated American Engineering Societies.

PROBLEMS, EXERCISES, AND TEST QUESTIONS

1. How is your work at this moment affected by the following Conditions: desk, ventilation, noise, seat, light, heating, and crowding?

2. Is it easier for a right-handed or a left-handed man to write English? Fully explain the reasons for your answer.

3. Describe a room that is well adapted for a student to study and sleep in. Illustrate by sketches sufficiently for clearness.

4. "What effect do the Conditions surrounding the workman in the shop have on his morale, production, and workmanship? Give your reasons."[1]

5. Draw up a questionnaire to be issued to students at your institution, to secure information on their living Conditions. Write a letter from the Dean of Men to accompany the questionnaire.

6. Write a report on your experience in the Adaptation of your personal Conditions. The mark will be based on the experience shown.

7. Write a theme on the application of Adaptation of Conditions to athletics. Draw all possible lessons for the industrial manager from these applications.

[1] Foreman's Training Course of the Pennsylvania Railroad.

8. Write a theme on the application of Adaptation of Conditions to a fraternity or other student society. Draw all possible lessons for the industrial manager from these applications.

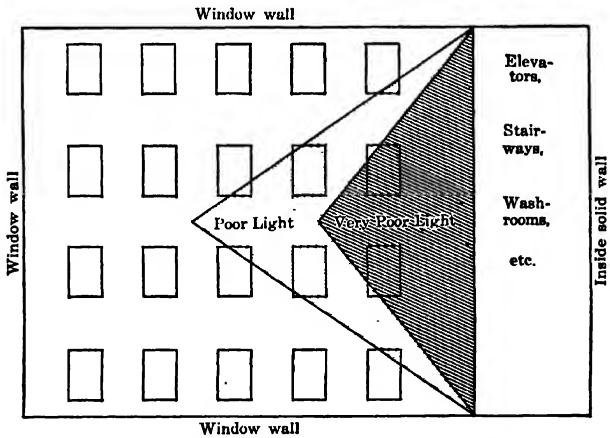
9. Write a specification for the steel for the crown sheet of a locomotive. Explain why you specify as shown. Explain briefly how you would inspect to enforce the specification. Free use of all texts and of an engineering handbook is allowed.

10. Discuss the relation between cleanliness and the mass production within close limits of tolerance.

11. Draw from the instructor an illustration of an industrial building or shop, such as may be found in any technical periodical, and report whatever it suggests to you under Adaptation of Conditions.

12. Rearrange to the best advantage the workroom shown in the following illustration. Sketch to approximate scale.

There is a sewing machine and table at every work place, marked thus: □. All operations are identical and indivisible. All space not occupied by machines, tables, and operators is required by aisles, work in process, and inspection. Inspection can be done by artificial light.



13. Explain the good and the bad points of some industrial building with which you are acquainted, and give reasons for your opinions.

14. Why is ---- (fill in name of place) a center of the ---- (fill in name of product) industry?

15. Write a theme on machinery for the mechanical handling of materials and discuss its economic value.

16. What does the following time study suggest to you as feasible measures for the increase of production?

DATE: 3/1/21
MACHINE: Allen four-spindle drill press (south machine)
PLANT: ______ _____ _____
PIECE: No. D-199R

OPERATION: Drilling 3 holes (done in drill jig)
NUMBER OF PIECES IN ONE LOT: 425
Hand feed

MAIN CYCLE

Operation	Time in Minutes: Actual	Time in Minutes: Standard	Remarks
1. Pick up piece from table of machine	.040	.031	
2. Insert piece in jig	.03	.03	
3. Set up locating screw	.041	.041	
4. Place jig under first spindle	.014	.011	
5. Drill first hole. Simultaneously move next piece from truck to table of machine	.35	.35	Three trials show no saving of time by having these pieces placed on table of machine for operator
6. Withdraw drill	.035	.03	
7. Move jig to second spindle	.019	.019	
8. Drill second hole	.174	.174	
9. Withdraw drill	.034	.034	
10. Move jig to third spindle	.022	.022	
11. Drill third hole	.191	.19	
12. Withdraw drill	.035	.035	
13. Move jig to right of table	.027	.027	
14. Open fixture	.043	.03	
15. Remove piece from fixture and throw piece into truck	.027	.017	Loss of time may be overcome by relieving jig, which is too tight
16. Shake out chips	.035	.033	
17. Brush chips off table	.015	.015	
Total	1.135	1.092	Time of 12 main cycles timed in total: 1.31, 1.23, 1.22, 1.23, 1.35, 1.22, .94, 1.03, 1.08, .97, 1.00, 1.067 } av. = 1.137

OVERALL OPERATION

Operation	Time in Minutes		Remarks
	Actual	Standard	
425 Main cycles	483.00	465.00	
Delay through broken belts			
On drill spindle	10.68		
On pump .	28.97		
Grind drills .	5.83	5.83	
Supply lubricant for cutting tool	1.64	1.64	
Move 425 pieces from tote box to table truck	6.73	6.73	
Start machine and turn on water .	.45	.45	
Delay through trouble with jig . . .	.65	.65	
Delay through drill's sticking in bushing	3.63	3.63	
Set drills	.22	.22	
	541.8	481.15	
Rest	.	53.46	
Total		534.61	

17. Write a theme entitled "The Adaptation of Conditions and Work to Each Other," dealing with a garage for motor vehicles.

18. Describe briefly the location of some industrial plant, including a free-hand sketch map of the site to approximate scale. Explain the advantages and disadvantages of this location.

19. Explain and illustrate by sketches the routing of material and work in process through any industrial plant. Criticize the routing shown, explaining its good and bad points.

20. Suggest means of increasing the standardization of equipment, methods, or product, or any combination of these, in some plant with which you are acquainted.

21. For any business subject to seasonal fluctuations, with which you are acquainted, report causes of such fluctuations and suggest means to diminish them, or to minimize their bad effects, or both.

22. Suggest means of reducing the cost of handling materials in some plant with which you are acquainted.

23. Explain the relation between Adaptation of Conditions and Work to each other and ____ (fill in the name of any other of the Thirteen Principles of Management).

CHAPTER VI

RECORDS; PLANNING AND DESPATCHING

77. Introduction. In the theory of management, Records is a principle separate and distinct from that of Planning and Despatching; but in practical application the two must be used together, because the planning of the future must be based on the records of the past. Therefore the development of Planning and Despatching carries with it the installation of immediate, adequate, and reliable Records.

Discussions of these two principles are apt to leave one with the feeling that his own needs have not been met. This results from the fact that their application has to connect so closely with the practical details of the work that any discussion is apt to deal so exclusively with some assumed or actual case that it has very little application to any other, or else to run to the opposite extreme and be composed of such generalities that it is very difficult to apply it to anything.

These two principles are like swimming, in that they can be learned only in doing the actual thing. However, no greater service can be rendered to a boy who is learning to swim than to teach him to get down into the water up to his nose and let the water support him. When he has mustered courage to do that, he finds that the water bears him with practically no effort on his part and that the stroke is of only secondary importance.

So it may be of service to indicate some principles of Records and of Planning and Despatching. If any manager will apply them and will get after his planning, despatching, and records with determination, he will find that the particular methods and forms that he uses in carrying out these principles are of only secondary importance.

The first development of Planning and Despatching was for the purpose of controlling production, but experience has shown that this principle must be fully applied to every activity. Limits of space oblige this treatise to confine the detailed de-

scription of technic to production. However, the student is referred to sections 52, 197, 232, and 303.

78. Standardization of forms. As to forms, there is about one chance in a million that any form can be transferred from one plant to another without redesigning it. In these sections it is therefore, in the main, put squarely up to the manager to design his own forms. Such discussion is given as may help him in so doing. Illustrative examples (not models) are given of a few forms which require only minor modifications in adapting them to a wide range.

Recently some interest in the standardization of forms has developed among business organizations. The ordinary form as used by the individual business is often very poorly designed. It is to be supposed that a standard form developed with care by the authorized representatives of large numbers of business organizations would be very much better designed. Provided a standard form is well adapted to very general use, it is to be expected that it would bring about the following economies in material and labor:

It would be generally understood, and therefore would reduce misunderstanding and inconvenience.

It would minimize clerical work.

It would reduce the amount of Instruction necessary for the clerical personnel.

It would save paper by cutting from standard-size stock without waste.

It would save filing space, as all forms would be Adapted to standard filing equipment.

In section 141 and Figs. 26, 27, and 28, attention is called to two forms which have been adopted as standard by a large number of national business associations, and which are recommended by the United States Department of Commerce. These two designs show the great difficulty in the way of general standardization of any form.

79. Planning and Despatching necessary. Planning is necessary for three purposes, as follows:

To prepare in advance for what is to be done
To coördinate all lines of activity so that they work together to achieve the common Ideal
To achieve results at the proper time

It is evident that failure to accomplish any of these three purposes must lead to loss.

Despatching is guiding the execution of the plans.

The young engineer-manager must be prepared to meet the idea, on the part of many older men, that planning is an outright addition to the work of the plant, and that whatever the planning system may cost is simply so much added expense. He should therefore realize that the work of determining priority of jobs, of deciding what jobs to put into work, of seeing that necessary preparations are made, and of recording progress and completion must be done anyway. It is obvious that these important functions can be performed better, more thoroughly, and at less cost by fewer people working in an office under Adapted Conditions, with specialized Organization and Records, and with the opportunity to develop special skill, than when they are attempted by people working on the shop floor without any of these advantages and subjected to many other duties and distractions. The mere fact that work is going on at all shows that there must be at least a crude, inefficient, and hence costly performance of these functions. Whatever performance there is constitutes Planning of some degree.

80. Chronological order of the development of Planning. Improvement of Planning and Despatching is often the first thing to attempt and a measure from which great gains can be derived very soon. This is true because of the great importance of foresight, of advance preparation, of coördination of work and of teamwork in the organization, and the impossibility of securing these except through Planning and Despatching.

It is important for the student to realize this; for it is natural to think that nothing can be done with Planning and Despatching until after Adaptation of Conditions is well advanced. One expects to have the track in thoroughly good shape before he undertakes to move trains on schedule time. However, if there is nothing but a wilderness trail, and transportation has to be done by pack animals, it is still important that the trips of the pack trains should be well planned. If the manager waits for a good Adaptation of Conditions before he undertakes to do anything with his Planning, he will probably lose the opportunity for early gains. **It is important to the manager and to the industrial engineer that he should show results promptly.**

On the other hand, if it is suddenly discovered that the plant is out of some needed articles of stores, plans are upset. If workers are continually leaving and new ones being taken on in their places, the uncertain and unskilled labor of green hands disarranges the plans. In short, every inefficiency in the plant interferes with planning. Hence planning cannot be perfected until every other principle of management has had its full application.

The importance of planning, and the possibility of early gains by improving it, mark it as one of the earliest steps of improvement. At the same time, its dependence upon every other element of management shows that it is impossible to introduce well-developed planning at the outset, that its development can only go step by step with other improvements, and that advantage ought to be taken of every other improvement to make some gain in planning.

As the works manager of a big textile plant once said, "Any fool can tear down an old mill, and any ordinary engineer can put up a new one; but to tear down an old mill, put up a new one on the same site, and keep all the looms going all the time takes a good man." That is about the problem that confronts the industrial engineer when he undertakes any considerable improvement of Planning and Despatching and of Records. The new system must be put in, the old one must be taken out, and production must be kept going all the time. Some industrial engineers have got themselves and their clients into grievous trouble at this very point, — by the breakdown of production between the old system and the new, — to the discredit of the new methods of management.

81. Tentative program. At this point a program will be suggested; but while, for the sake of brevity, this will be stated in exact terms, it is important for the student to realize that conditions differ so widely that he should by all means keep alert and do his own thinking. He should vary the program in any particular case as much as its peculiarities may require.

It is assumed that in the plant as found there is barely enough planning to keep things going. Actual cases vary all the way from that situation to those in which very good Planning and Despatching is already in existence. The program as given may therefore, in any particular case, trace steps which have already been taken.

82. Priority of work. A fundamental condition of efficient planning is definite, authoritative information to the shop executives as to the priority of work. In actual fact this is often lacking, and at the same time the shop executives are subjected to conflicting and insistent demands for delivery from many different sources. This leads to starting and stopping jobs in obedience to the last or most insistent or most authoritative demand, to tearing down set-ups only partly used, and to general inefficiency.

The complete establishment of definite priority of all work is an extreme Ideal, which can only be approximated. One hundred per cent attainment is impossible and probably undesirable. It is, however, both feasible and desirable immediately to publish the priority of the main jobs of the plant. An example of this is given in Fig. 8.

This is the basis of the entire planning of the plant. Its preparation is worthy of the personal attention of the General Manager himself. It is conveniently prepared at a routine daily meeting of the General Manager, the Factory Manager, the Sales Manager, the Financial Manager, the Chief of Staff, and such others as the General Manager may call. Such a meeting is needed for other purposes anyway (see section 296). Until there is a Chief Planner the Factory Manager should take the initiative in the daily preparation of the Order of Jobs, and should submit to every daily meeting his proposed Order for the next day. As soon as there is a Chief Planner the latter should take over these duties. The Order usually requires only very brief consideration by the meeting.

A copy of the approved order should then be furnished promptly to every immediate subordinate of the Factory Manager and of the Chief of Staff, to the Chief Draftsman, and to the chiefs of the laboratory staffs, to every superintendent and foreman, and to every departmental despatcher.

83. The Chief Planner. Immediately questions of the interpretation and application of the Order of Jobs will arise. This is a good point at which to put on a Chief Planner (commonly called Production Manager) and to have him begin to learn his job. It is very important to select a thoroughly competent man for this position, because the whole planning system must fail otherwise. For a while the daily preparation of the Order of

ORDER OF JOBS

Destroy previous lists.

Jan. 3, 1919.

(Jobs having immediate right of way)

Serial No.	Job No.	Customer	Completion date required
1	592	Michigan T.T.Co.	1 - 19 - 19
2	361	Bouker	
3	637	Michigan T.T.Co.	

(After jobs having immediate right of way, the following have priority in the order of their serial numbers.)

Serial No.	Job No.	Customer	Completion date required
1	789	Matioka	1 - 10 - 19
2	1123	Lambert	1 - 12 - 19
3	1005	Westover	1 - 11 - 19
4	672	Mugford	1 - 14 - 19
5	671	Montgomery	1 - 4 - 19
6	969	Ward	1 - 21 - 19
7	739	Ohio Mfg. Co.	1 - 21 - 19
8	711	Ohio Mfg. Co.	1 - 21 - 19
9	521	Hull	1 - 11 - 19
10	276	R. L. Barnes	1 - 8 - 19
11	1876	Lykins	1 - 25 - 19
12	957	Wando	
13	343	Balch	1 - 31 - 19
14	369	Caldwell	1 - 31 - 19
15	Miscellaneous urgent jobs		
16	1010	50 ft. steamers, new type	
17	9193	Old power plant, installation of new units	

(New jobs to be started soon)

Serial No.	Job No.	Customer	Completion date required
1	633	Massachusetts Motor Co.	2 - 4 - 19
2	911	Vermont Tractor	
3	579	Noderlanden	2 - 8 - 19
4	320	Arkansas Farm Imp. Co.	1 - 31 - 19
5	463	F. L. A. & D. Co.	3 - 4 - 19

By order of the General Manager

William Brown
Chief Planner

FIG. 8. Priority list showing successive order in which the various jobs in a plant are to be completed

Jobs, and answering the questions which the foremen and others will ask in their efforts to apply it, will give him plenty to do. As the planning system develops he can gradually take on other duties.

84. Order-chasers. The next step in the development of Planning and Despatching may be the installation of the rudimentary planning staff, known as "order-chasers" or "stock-chasers." These should be the immediate subordinates of the Chief Planner. Their duties are to watch the progress of orders; to call to the attention of the shop executives — and, if necessary, to report to the Chief Planner — any work that is lagging; to trace needed parts, stock, and material; and, in general, to act as the direct representatives of the Chief Planner, to maintain the necessary watchfulness over such orders as must come through on a close schedule.

Order-chasers are very convenient as a temporary makeshift; but, as a main reliance for planning, they are properly only that because any reasonable number of them cannot follow up more than a few of the most important orders. Men should be selected for order-chasers who will be fit for permanent positions in the final planning organization, and their experience in chasing orders should be used to develop them for those positions.

85. Starting Planning. In starting Planning it is not usually possible to take up orders which are already in the plant. It will probably be necessary to take up only new ones as they are issued, and to allow those already in the shop to work themselves out by former methods.

86. Correct Method for design of forms. In order to help the foremen to fulfill the delivery dates required by the Order of Jobs, Despatching ought to be got under way in their departments as soon as possible. There is a form of Record which is so useful in this connection, which serves so many other purposes as well, and at the same time so economizes clerical work that it ought to be explained at this point. The student should note this explanation because it exemplifies the Correct Method for the design of forms.

The clerical forms of a business concern are often very poor examples of design. In fact, they seem often to have grown up haphazard rather than ever to have been designed at all. It should be realized that clerical forms are to all the routine ad-

ministration of a business what jigs and fixtures are to the work of a shop, and they are worthy of corresponding care in design.

As always, the first principle to apply is that of Ideals, by settling definitely what is the purpose of the form; that is, what it is to accomplish. The problem, in connection with every operation, is to get in one job of clerical work an immediate, adequate, and reliable Record of every item of information that is wanted and to furnish everyone needing records of that operation with the information that he needs. The first question then is, Who needs information? The next is, What information does he need? The answer to the second question assembles a statement of all the items that it is necessary to record. By recording the facts as to all of these on one form we get them all in one job of clerical work.

A record should pass as directly as possible from the person reporting to the reviewing officer. It should not pass from hand to hand on the way, except to receive supplementary notations. It is common to route a report from one reviewing officer to another. This practice introduces serious delays in the receipt of information and introduces a risk of serious trouble through the loss of the form on the way. At the point of original record a copy should therefore be made for every reviewing officer and should pass directly to him. The number of persons who need the information is therefore equal to the number of copies to be made.

In order to get all these in one job of clerical work, some method of duplication must be employed. This must be decided at this point because the method of duplication often influences the design of the form. The most common method of duplicating shop forms is by means of carbon paper, either by inserted sheets or by having the forms on paper with a carbon back.

The various items of information which it has been decided that the form must carry must then be arranged in the proper order on it. The most prominent positions on the form should be reserved for the items by which it is to be indexed or filed. In most visible files the bottom of the form is used for this purpose; in other forms of files the top line.

The size of the form must next be decided. The first consideration here is that the form must be large enough so that the information to be entered on it may be clear and legible.

Reducing the size of a form below this in order to save paper is false economy. The way to effect a real economy of paper, without impairing the usefulness of the form, is to make the latter of such size that it will cut without waste from one of the standard sizes of paper sheets. The form should also be capable of filing in one of the standard sizes of filing equipment; and unless there is a marked gain to be derived from a contrary practice, this size should be uniform with those already in use in the office.

Next must be settled the distinguishing marks of the various copies to be made at one writing. It is common to use paper of a different color for every copy; but if there is any considerable number of copies, it is difficult to avoid colors which make it hard to read the form. In that case it is probably better to distinguish the copies by printing prominently on each the name of the department to which it is to go.

87. The instruction card. To make the matter clearer, it is illustrated (see Fig. 9) by the design of the form referred to in the first paragraph of section 86.

Ordinarily the persons who need records direct from operations in the shop are the paymaster, the cost accountant, and the planner. We may conveniently arrange in tabular form, as in Table IV, the information wanted by each of these in the case illustrated by Fig. 9.

In this case all the operations performed in the department are listed at the bottom of the card and numbered. "Operation No.," in the fourth line of the card, is filled in by number only. This is convenient in the use of the card; but if any considerable amount of time will be required to prepare the numbered list of operations, it will be better to put the cards into use without it, and to denote the operations by the names by which they are commonly known in the shop. However, operations should be given some definite designation as soon as that can be done without delaying more important work.

In general, there is considerable advantage in printing on the form as much standard information (like this list of operations) as possible. Writing a short number or merely checking the item recorded is much more legible than the full data written by hand. It also speeds up both the writing of the form and the use of it as a Record.

Instruction Card No.				Date	
Dept. No.		Employee { No. / Name			
Start	Cont.	Fin.	Mach. No.	Sched. No.	Order No.
				Operation No.	

Details	Stand-ard	E	
	Time Finished	W	
	Time Started	B	
	Time Elapsed	H	

1 Alter	7 C. Sink	13 File	19 Grind	25 Oil	31 Repair	37 Shellac	43 Spin	49 Touch up
2 Anneal	8 Cut	14 Fit	20 Knurl	26 Polish	32 Rivet	38 Size	44 Stamp	50 Trim
3 Assemble	9 Decorate	15 Flatten	21 Lacquer	27 Prepare	33 Rough	39 Slip	45 Straighten	51 Tune
4 Buff	10 Dip	16 Form	22 Lap	28 Press	34 Route	40 Slot	46 String	52 Turn
5 Burnish	11 Drill	17 Gild	23 Make	29 Punch	35 Sand	41 Solder	47 Tap	53 Wash
6 Burr	12 Face	18 Glue	24 Mill	30 Ream	36 Saw	42 Sort	48 Thread	54 Miscell.

FIG. 9. Instruction card

TABLE IV. DATA WANTED FROM INSTRUCTION CARD

BY PAYMASTER	BY COST ACCOUNTANT	BY PLANNER
Date	Date	Date
Department	Department	Department
Employee		Employee
	Whether job is started, continued, or finished	Whether job is started, continued, or finished
		Machine used
		Schedule number[1]
	Order number	Order number
	Operation	Operation
Standard time of operation	Standard time of operation	Standard time of operation
		When work began ("Time Started")
		When work ended ("Time Finished")
Time elapsed on work	Time elapsed on work	Time elapsed on work
	Equipment rate, or hourly cost of running the machine used (E)	
Wage per man-hour (W)	Wage per man-hour (W)	
	Hourly burden (B)	
	Man-hours of labor on job (H)	
Special information in particular cases, included under "Details"	Special information in particular cases, included under "Details"	Special information in particular cases, included under "Details"

"Wage per man-hour" multiplied by "Time elapsed" gives the paymaster and the cost accountant the direct wages on the job. "Standard" divided by "Time elapsed" gives them the efficiency. If a system of bonus payment dependent on the efficiency is used, the latter, by reference to a bonus table, gives them the percentage of bonus. The direct wages multiplied by the percentage of bonus gives the bonus due on the job.

The information wanted will, of course, vary according to local conditions. Other information commonly wanted from the instruction cards is given in Table V.

Tables IV and V are not offered as exhaustive in all cases. The proper procedure is to list the information wanted, as is done in these tables, being careful to call for only needed information, and then to design a form to contain it.

Supposing, as is commonly the case, that only the paymaster, the cost accountant, and the planner need reports, three copies

[1] An example of a schedule is given in Table VII, sections 104 and 105.

are enough. Three sets of file records originate from the three copies of these cards, and for the sake of distinction between the files and of uniformity in each of them it is convenient to make each of the three copies on paper of a different color. They are then padded in sets, into which the clerk inserts the carbon papers for making all three copies at one writing. In the regular use of the cards one copy of each will go to a workman as his order to do the job, or instruction as to its performance, — whence the name "Instruction Card," — and will be returned by him as his report that he has ceased work on it. The card for this purpose needs to be rather heavy, and its thickness puts it at the bottom of each set in padding, in order that carbon copies may not have to be made through it.

TABLE V. OTHER DATA COMMONLY WANTED FROM INSTRUCTION CARDS

BY PAYMASTER	BY COST ACCOUNTANT	BY PLANNER
	Article or part in work	Article or part in work
		Amount ordered
	Number of pieces completed	Number of pieces completed
	Brought forward from previous cards	Brought forward from previous cards
	On this card	On this card
	Total	Total
	.	Responsible inspector
Other workers employed simultaneously in case of gang operations	Other workers employed simultaneously in case of gang operations	Other workers employed simultaneously in case of gang operations
		Designating symbol of proper Standard Practice Instruction (see section 113)

88. Decentralization of Planning. In the first development of Planning and Despatching, industrial engineers tried to centralize very closely, and to put very detailed control of the progress of orders into the hands of a central planning office, which was necessarily removed from close contact with the shop. It was only in very rare cases that Adaptation of Conditions could be carried to the degree of standardization necessary to make such a plan workable. Therefore industrial engineers now decentralize planning. Usually the central plan-

ning office will not specify to the shop department more than the departmental delivery date, and will leave to its foreman the detailed planning and despatching from machine to machine and from operation to operation within the department.

In order that a foreman may be able to plan and despatch work within his department he should, unless his department is very small, be given the assistance of a clerk (known as a despatcher) for that special purpose.

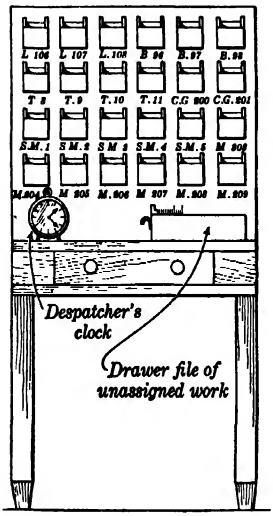


FIG. 10. Despatcher's table and small despatch board

89. The despatch board. It greatly facilitates the work of the foreman and of the despatcher to provide them with a board called the despatch board, on which to distribute the jobs to the different workers of the department. This board may be built in a large variety of forms. In Fig. 10 is shown a despatcher's table with clock, drawer file of unassigned work, and a small despatch board. Fig. 11 shows a view of one pocket to a scale of about two inches to the foot. Usually a despatch board contains two pockets, or receptacles, for every worker, one of which is here called the stand-by pocket, and the other the reserve pocket. The despatcher, with desk and despatch board, should be located in some place easily accessible to the workers. One despatcher can serve about one hundred workers, and may despatch for several foremen.

There should always be a card in the stand-by pocket of the board for the next job that the worker is to do. When a man stops work on a job, he should deposit the card for it on the despatcher's desk as his notice to the latter that he has ceased work on it, and should take his card for the next job from the stand-by pocket.

This involves the worker's walking to and from the despatch board every time he changes his work. Where previously the work has been very poorly planned, this may mean at first that

the men have to change their cards very often, — which is, of course, a nuisance, — but this is a condition which needs to exist for only a short time, during which it can be tolerated for the sake of results to follow. When planning is going right, a worker's jobs will be assigned to him in runs of at least one hour. When this is accomplished the amount of time that he spends going to and from the despatch board is negligible. Moreover, it is a mistake to suppose that it increases a man's efficiency to root him to one spot for hours at a time. He needs to stir about once in a while to relieve the monotony, and his efficiency is increased by doing so. This is discussed further in sections 132, 134, 326, and 328.

When a man takes his card for the next job, he carries with him only the heavy card. The others remain at the desk as a record for the job in work. A good place for them is at the back of the reserve pocket, behind all other cards. The despatcher should be responsible for placing them correctly.

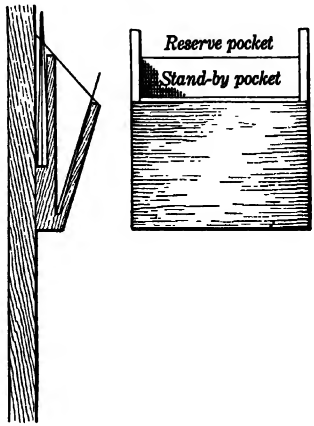


FIG. 11. Detail of one pocket of despatch board

It is usually a good plan to begin departmental despatching by setting up the despatch board and having the men report to the despatcher and change their cards with every change of jobs. The despatcher should record these changes on the cards from the men's reports, while at first allowing the workers to receive their orders just as they have done before and continuing the previous system of job records. The purpose of this is to accustom the men to the use of the board and to teach the despatcher to keep the records. This should be accomplished before anything is made to depend upon the use of the cards. When the despatcher has learned his work thoroughly, the previous system is discontinued, and the despatch board and instruction cards are put into full use and force. In general, a new system must be put into use and be fully established before the old one, whose place it takes, is discontinued.

The despatcher makes his record by filling in "Time Started" (Fig. 9) when the man takes the card, and "Time Finished" when he returns it. The despatcher then fills in "Time Elapsed" equal to the interval. "Start," "Cont.," and "Fin.," in the third line of Fig. 9, are for the information of the planning office. When a man takes a card, the despatcher strikes out "Cont." and leaves "Start" if the man is starting the job. If it is an old job continued, the despatcher strikes out "Start" and leaves "Cont." When the man returns the card, the despatcher strikes out "Cont." and leaves "Fin." if the job is finished. If the job is not finished, the despatcher strikes out "Fin."

90. Instruction of foreman. At this stage the foreman will need considerable Instruction. The industrial engineer who has direct charge of installing the planning will do well to be on the ground himself until the foreman has thoroughly mastered the subject. Sometime during the course of the installation it will be a good plan for the engineer to codify the oral teaching into a written Standard Practice Instruction.

The following is abridged from such a written Instruction issued to the foremen of a large machine shop:

1. *Execution of work. a.* As far as possible, assign work to the machine best adapted to it. Small work should be placed on a small, fast-running machine,—not on a slow-moving one of large capacity.

b. Find out the class of work and the machine to which each man is best adapted and which he likes best, and then, as far as possible, avoid changing him from that machine. (As this was a repair shop, the work was nonrepetitive, so that the problem was to obtain sufficient specialization, not to avoid excessive monotony.) This is not intended in any way to prevent a man from getting general experience if he desires it and is worthy of it.

c. Keep each machine supplied with at least one job ahead, placing materials at the machine, and an instruction card in the stand-by pocket of the despatch board, as far in advance of the completion of the job in work as practicable. See that completed work is promptly taken away from every machine.

d. Coöperate with the inspector attached to your section to secure preventive inspection, in order to keep down your scrap loss and maintain a high quality of work.

e. (This paragraph explains the detailed process of despatching by means of the board and the instruction cards as explained in sections 89 and 91, and it is therefore not repeated here.)

f. It is important that instruction cards be sent to the planning office as promptly as possible after completion of the job, as the accuracy of the machine control board (see section 120, Harrison's Machine Group Planning and Control Board) and the progress records (see section 121) depend upon the prompt return of these cards.

2. *Securing proper sequence of work.* It is very important that you select jobs for assignment to machines with due regard for the delivery dates given by the daily Order of Jobs. Otherwise it will be impossible to meet these dates. If you think that any such date cannot be met, call the Chief Planner at once on the telephone and report the fact. At the same time you should plan your work so as to secure the lowest cost. An important means to this end is to run jobs requiring the same set-up one after the other, without changing the set-up.[1] Low cost may sometimes cause you to run a less urgent job in preference to a more urgent one, but this should never be carried to the point of causing us to break a promise of delivery.

91. Departmental Planning and Despatching. As soon as the use of the despatch board has been learned, we can start despatching the work in the department so as to fulfill delivery dates set by the Order of Jobs.

The foreman should take his order for a job and analyze it into the separate operations required in his department. If possible these analyses should, as soon as convenient, be standardized according to Correct Methods, and should then be recorded in the "Master Schedules," or "Standard Operation Sheets," of which an example is shown in Table VII, pp. 134–135.

When the work of a department is approximately covered by such Master Schedules, it will probably be desirable to transfer the original writing of the instruction cards to the central planning office (see section 113). Referring to Fig. 9, p. 113, "Date," "Employee," "Start," "Cont.," "Fin.," "Mach. No.," "Time Finished," "Time Started," and "Time Elapsed" would then be left blank, to be filled in by the departmental despatcher.

The exact methods of departmental planning and despatching will vary a great deal according to the construction of the boards, local conditions, and individual preference. It is absurd to be insistent about such minor matters, but the following methods are suggested as simple and practical.

[1] The student's attention is called to this as a matter that foremen are particularly apt to neglect.

Returning to the early stages of a planning installation, the despatcher should make out a set of cards for every operation, according to the foreman's analysis as above stated, filling in "Instruction Card No.," "Dept. No.," "Order No.," and "Operation No." as matters of routine. If the job is to be put into work for the first time, the despatcher should strike out "Cont." If work has been started on the job and has been interrupted, he should strike out "Start" on the card which orders work to be continued. This is made for the information of the Planning Department. He should then file the set of cards, fastened together by a binding clip, in a file of unassigned work ahead.

As often as the foreman's other duties will allow, he should look over this file of unassigned work. In connection with every instruction card he should consider what, if anything, renders the operation unavailable for work. Whatever it is — lack of material, machine down for repairs, or workmen absent — should have his attention in order to make the operation available, the more urgent work being given the preference. As soon as he has made the operation available, he should notify the despatcher of a tentative assignment of the work to an individual worker or to a machine, or to a straw boss in the case of a gang operation. The despatcher should then file the set of cards in the reserve pocket of the man to whom the foreman has tentatively assigned the work.

As soon as possible after the workman has taken his card from the stand-by pocket, thus signifying that the job is in work, the despatcher should obtain from the foreman his assignment for the next job, and should place the workman's card for it in the stand-by pocket. He should then fill in "Employee No." and "Name." According to the circumstances he may either fill in "Machine No." then or wait until the workman draws the card from the stand-by pocket.

The despatch board thus handled becomes a picture of conditions in the department. As such the foreman should take a keen interest in it and should often inspect it. When the foreman is assigning the operations for any order, the cards in the reserve pocket show how much work is ahead of every man, gang, and machine; and the foreman, in assigning new jobs to those that can do the work, will naturally give the jobs to those that have the least work ahead of them. Or, if two men can do

the operation, and their reserve pockets show that one has much more work ahead of him than the other, the foreman can transfer some work from the overloaded to the underloaded worker.

The foreman ought to arrange the cards for as many as possible of the jobs ahead in the reserve pockets, in the order in which they are wanted. If two or more men do the same operation, and the reserve cards immediately ahead of one show only jobs that are not wanted soon, the reserve pockets of the others should be examined to see whether any jobs that are wanted soon are in them with several other jobs ahead of them. If so, they should be transferred to the reserve pocket of the first worker, and placed ahead of the jobs in it that can wait.

If cards are arranged in the reserve pockets in the order in which the jobs are wanted, then when a man takes his card from the stand-by pocket the despatcher will at once transfer the workman's card for the next job from the reserve pocket to the stand-by pocket. When the workman's card is thus transferred from the reserve to the stand-by pocket, if there are no cards left ahead in the reserve pocket the despatcher should at once notify the foreman to that effect, in order that he may be on the lookout for work for the man who is in danger of running out of work.

The cards ahead in the reserve pockets show also for what jobs soon to go into work set-ups have to be made, what tools have to be got in order for them, and what materials have to be moved and to what machines. In general they give warning of all preparations that have to be made in order to keep the department running smoothly.

It is evident that the despatch board, if used in this way, enables a foreman to watch his department much more closely than he could without it, and that it can therefore effect valuable results even if conditions are very far from being adapted to the work, and even if the foreman's guess is the best information available as to how long it will take to do any job.

When a man takes his card from the stand-by pocket, the despatcher should fill in the date and the hour as "Time Started" in hours and tenths of hours of working time from the beginning of work for the day or the shift. A clock with its face reading in hours and tenths of hours from beginning of work,

and for working hours only, is easily and cheaply provided, to facilitate this and to decrease the chances of error.

As soon as the standard time has been determined for the job, and Efficiency Reward has been introduced, the despatcher should fill in "Standard" on the card before it goes to the worker. This enables the latter to see what pace he has to attain to earn the reward. It enables him, further, to see that his making a good efficiency does not lead to cutting down the standard time (see also section 454).

When a worker returns his card, the despatcher should fill in "Time Finished," subtract "Time Started," and put down the difference as "Time Elapsed." If the job is not finished, the despatcher should strike out "Fin.," thus notifying the Planning Department that work remains to be done on it. At the close of every working day or shift the despatcher should make out continuation cards for the jobs which are not finished, and should fill the stand-by pockets of the despatch board in readiness for the next day or shift.

In order that the Planning Department may know where it stands, the despatcher, as promptly as possible after the close of the work of every day or shift, should turn in to the Chief Planner, via the Chief Despatcher (see section 123) all his cards that were in work on that day or shift. Before doing so he should reassemble every worker's cards with the other cards of the set, and should clip the three or more cards together again.

"Sched. No." will probably not be filled in when the cards are first used, because usually there will not yet be any schedules (see sections 104–108). Special information under "Details" should, of course, be filled in as circumstances may require.

92. Variations from ordinary procedure. The method of starting Planning and Despatching given above should not be considered as an invariable procedure, but should be modified as may be necessary to get the best results.

If a foreman has a very large department, or one in which the technic of the work requires a great deal of his attention, it may be necessary to give him a skilled departmental planner who can relieve him altogether of the details of departmental planning and despatching.

On the other hand, a foreman may be able to handle a small department without any assistance. If the department is very small, or the foreman has a very good memory, he may be able to plan and despatch so well in his head that any formal system would be mere red tape, except in so far as it is needed in order to provide the office with necessary records. A similar condition occurs where the department carries on a continuous process on only a small variety of articles, in which case planning may be done once for all, and a definite routine established by which the work flows automatically in a continuous stream.

In some cases it may be advisable, instead of having a central despatch board, to have pockets for the cards located at or near the mens' work places, especially if such receptacles already exist and the foreman has been accustomed to place orders for the men in them. In the latter case the use of the separate pockets at the work places involves less of a change from previous methods, and therefore the men more readily adopt it. This method has the disadvantages, however, of taking more of the despatcher's time, thereby reducing the number of men that he can serve, and of making it more difficult for the foreman to get a bird's-eye view of the condition of his department unless a duplicate board is maintained for that purpose. Also the chances of error are increased, and further demands are made on the time of the despatcher to maintain the duplicate despatching.

If the work has been very poorly planned before, so that the workers change their jobs very often, it may be necessary for the foreman first to learn to use the board for planning his work, meanwhile continuing to give his orders by previous methods, and not to have his workers begin to use the board until he has learned to plan his work so well that they will have to change their cards with only reasonable frequency.

Under special circumstances it may be necessary, instead of taking a whole department onto the despatch board at once, to take it on gradually — a gang, or a few workmen, or even only one workman at a time. In such a case the extent to which improvement should go with each lot before the next is taken on is entirely a matter of expediency and special judgment.

Sometimes it may be necessary to take the departmental planning and despatching first, at least for some departments,

before starting even the crude central planning outlined in sections 70 to 77. The important thing always is to apply the principle. Devices and methods are secondary.

93. Final disposition of instruction cards. Reference to Table IV shows that ultimately, as the despatcher makes his last entries on every set of cards, they contain all the information needed by the Paymaster, the Cost Accountant, and the Planning Department except E, W, and B. These last are permanent information and should be kept on file by the Planning Department.

The Planning Department should fill out E, W, and B. H, the man-hours on the job, is the sum of "Time Elapsed" derived from the cards of all the workers employed on it. The Planning Department should promptly complete the instruction cards and then forward the Paymaster's and the Cost Accountant's copies to them (p. 164, sect. 121, first par.). After those officers have used their copies for making out the pay and bonus rolls and for costing, respectively, they should place them on file. The Paymaster's copy should be filed by workers. In this way there is built up in the pay office a complete record of everyone. The usefulness of this is stated in sections 221 and 235. The Cost Accountant's copy should be filed according to whatever designation will be most valuable in the system of cost accounting employed, as a permanent detail record of costs. It is common to file the Cost Accountant's copy by order number, but a classification by processes is usually more valuable (see section 139). If costs are kept by processes, obviously a file of instruction cards by processes gives the readiest reference to these basic cost records.

The same copy of the instruction card that has been used by the worker in the shop should be retained by the Planning Department. This copy is usually the least legible of the three, and should go to the department which, from familiarity with its content, can read it most easily. It informs the Planning Department of progress in the performance of its plans, and enables it to make such revisions of them as the facts require.

After this has been done, this copy of the card is of no further interest to the Planning Department; but it is a good plan to keep it on some permanent file from which needed information can be readily obtained. For example, in the distribution of

burden and the determination of hourly rates of equipment, and in revising plant layouts to get the most efficient routing, information as to the exact amount of use of every piece of equipment is needed. This card may therefore be filed by machine numbers, unless some better use for it is apparent.

94. The time-clock card. Fig. 12 shows a record which is almost always kept, with minor variations in form. The worker, in passing in or out of the shop, inserts the card in the time clock (which is always situated near the door), and the clock prints the time in the proper space. The worker deposits the card in a rack marked "In" or "Out," as the case may be. In this way there is accumulated a record of his attendance. There is no information on the clock card which could not be obtained from the worker's instruction cards; hence it looks like a duplicate and unnecessary record. In some cases industrial engineers have discontinued it after departmental planning and despatching was going well. It is, however, a good plan to maintain the clock card. Since the total of the "Time Elapsed" on any worker's instruction cards for a day should equal his total time present as shown by the clock card, the latter gives a valuable check on the former. Moreover, the clock cards

WEEK ENDING ____________

NO.

Name ____________

DAY	MORNING		AFTERNOON				TOTAL
	IN	OUT	IN	OUT	IN	OUT	
SUN.							
MON.							
TUE.							
WED.							
THU.							
FRI.							
SAT.							

TOTAL	HRS.			
PIECE	HRS.	PIECE		
DAY	HRS.	DAY		
RATE	PER HR.	TOTAL		

FIG. 12. Time-clock card

remaining in the "Out" rack after work is started show at a glance what workers are absent; and it is convenient for the foreman and the despatcher and others to have this information.

95. The exception card. In spite of all that can be done toward the Adaptation of Conditions, interruptions and delays will sometimes occur. The standard times set for work should include a reasonable allowance for such minor interruptions of very short duration as cannot be avoided. Beyond that, it is seldom possible to pay any attention to them. Occasionally a serious delay will occur from causes that cannot be foreseen.

When any serious interruption occurs, the workers who are delayed by it should receive a special card. It is convenient to make this card similar in form to the instruction card, but of different color, to distinguish it, and with the title "Exception Card" or "Allowance Card" instead of "Instruction Card." It should clearly state the nature of the interruption and its cause, if known. The exception card should preferably state the time of the beginning and end of the interruption and the time elapsed, though where an excessive amount of clerical labor would be required to record these times it may state only the time elapsed.

The three copies of the exception card should follow the same routing as the corresponding copies of the instruction card. The Paymaster's copy should be filed by workers, in order that that file may contain a complete record of every worker's time. A similar principle applies to the Planning Department's file by machine numbers. The Cost Department should file its exception cards by themselves for convenient use, as stated in the last paragraph of this section.

In some cases it is not practicable to have the direct workers change their instruction cards at the beginning and end of the interruption. For example, suppose that the power goes off for six minutes: the loss of this time might seriously lower a worker's efficiency, but it would only lower all efficiency still more to have every worker in the shop change his card at the beginning and end of the interruption. Instead the despatcher should make out an exception card for every worker. This should give the duration of the interruption and, if possible, its cause (in this case "Power Off"), and preferably the time when it began and when it ended.

In all calculations of actual time from the instruction cards, the exception cards for the date should also be seen. If any cases are found where the instruction cards have not been changed before and after the interruption, the time covered by the exception cards should be subtracted from the actual time shown by the instruction cards.

The Cost Department, at the end of every cost period (usually one month), should summarize the expense due to the delays shown by the exception cards for the period, as a separate item of indirect expense, or overhead. The use to be made of such summaries is stated in section 44. This is important. **The cost of idle time is one of the most serious wastes in American industry.** When a man or machine is idle, that large part of the cost of work known as indirect expense, or overhead (see sections 155 and 156), — usually amounting to at least half the total cost, — continues just the same as if work were in progress. The reason for so much idle time in industry is that, as much of it occurs in driblets, the management does not appreciate how much loss it causes in total and does not make adequate efforts to prevent the loss. If this total loss is brought to the attention of the management by such means as are recommended in sections 44, 182, 184, and 185, serious efforts will be made to prevent this loss, and it will be found that much of it is preventable.

96. The requisition. In order that materials may be entirely under control, and also in order that responsibility for them may be properly located, all materials must be drawn from the Stores Department on written requisitions.

These requisitions are conveniently made in form very similar to the instruction card shown in Fig. 9, section 90, and are designed on the same principles. Supposing that a bonus is paid for efficiency in the use of materials, the fundamental data needed for designing a requisition card in such a case are given in Table VI on page 128.

The paymaster's data enable him to calculate the actual and standard costs of the materials for the job and the value of by-products, if any, with which the workman is to be credited. These form the basis of the bonus on materials, as is explained in section 448.

TABLE VI. DATA WANTED FROM REQUISITIONS

By Paymaster	By Cost Accountant	By Planner
Date	Date	Date
Workman's number		Workman's number
	Article	Article
	Kind of material	Kind of material
	Quality of material	Quality of material
Amount of material used	Amount of material used	Amount of material used
Standard amount of material for job	Standard amount of material for job	Standard amount of material for job
Unit value of material	Unit value of material	
	Order number	Order number
		Machine number or other designation of place where material is to be put in work
	Amount of main product	Amount of main product
Value of by-product	Amount and value of by-product	Amount of by-product

When planning is first started, as the Central Planning Department's control is still unavoidably somewhat loose, it will probably be best to furnish the departmental despatchers with blank requisitions for material. Inspection of the file of unassigned, or unavailable, jobs from time to time gives warning when any job is approaching the need for material; and the despatcher, under the direction and by the authority of the foreman, can then make out the necessary requisitions and forward them to the storeroom. At this stage of installation the least of possible evils is to give the foreman a pretty free hand in ordering material.

97. The Delivery Tag. In order to guide the movement of material about the plant and to determine responsibility for it during such movement, certain other records are necessary. The first of these is the Delivery Tag.

The student should remember that any form must be modified to suit the circumstances of its use, and **he should not seek to memorize forms but to understand the principles of their design and be prepared to design forms to suit his own needs.**

Figs. 13, 14, and 15 show the Delivery Tag as it is used in a large plant consisting of many detached shops. The parts shown in the three figures are coupons of one heavy manila tag, separable from one another along lines of punched holes.

The serial number on all three coupons (in this case 38051) serves to identify one with another as parts of the same tag whenever it becomes necessary to trace any material. The material is delivered to a space reserved for outgoing material in the storeroom or shop which is sending it out. The shipping clerk of that department makes out all three coupons. A truck from the Transportation Department calls and loads with the material from the outgoing space. The driver punches the "Outgoing Plant-Delivery Tag" (Fig. 15), tears it off, and hands it to the shipping clerk. The latter forwards it to the despatcher of that department, who files it as the Transportation Department's receipt for the material.

The driver delivers the material to the destination shown by the tag. He there deposits it at a space reserved for incoming material. The receiving clerk signs the middle coupon (Fig. 14), tears it off, and delivers it to the driver. The latter delivers it to the Transportation Office,

38051 O DELIVERY

JOB ORDER NUMBER	ITEM	DATE

Drawing No. .... Piece No. ....

FROM ....

No. Pieces or Containers and Description

38051

FIG. 13. Incoming Plant-Delivery Tag Stub

38051

Date ....

From ....

To ....

Received by

....

(Signature of Receiving Clerk)

FIG. 14. Transportation Department's Coupon

JOB ORDER NUMBER	ITEM	DATE

Drawing No. .... Piece No. ....

TO ....

No. Pieces or Containers and Description

38051 To be Punched by Driver

FIG. 15. Outgoing Plant-Delivery Tag

and it is there put on file as the receipt of the department which has received the material.

The receiving clerk tears the "Incoming Plant-Delivery Tag" at the line of holes shown by dots and forwards this part to the despatcher, to notify him that the material has been received. The latter notes the fact on the instruction card for the job and forwards this coupon to the Central Planning Office. This office posts the information against the job on its progress record, under "Material, Source, and Receipt" (see Fig. 22 and section 121, "Progress-Card Clerk" and "Detail Record of Progress"), and files the coupon in the permanent record of the job. This assumes, of course, that the Central Planning Office has been developed to a point not yet described in these sections.

The last part of the tag, containing no record except the serial number, remains with the material for purposes of identification.

98. The Route Tag. This is simply a good, strong tag, to be wired to the material or to be carried in a pocket in the container, or tote box. About the only thing which it requires in the way of form is the shop-order number and lot number of the job for purposes of identification. If the order is complicated and carries many lots of material, the Route Tag should bear serial numbers, and the "Tag No." of every lot should be recorded on the progress card (Fig. 22). The Route Tag will probably not come into use until the Central Planning Office is sufficiently developed so that it can list in advance the stations to which the material will pass during the manufacture of the order; so it belongs to a later stage of development than is here supposed. It is, however, convenient to describe it here in connection with the Delivery Tag. The Central Planning Office will list on the Route Tag the stations in order, and will send it, either directly or via the despatcher of the first operation department, with the requisition, to the storeroom. It will there be placed with the material, and will accompany it through the process, serving from station to station the same purpose as the address on a letter. Usually the Central Office should list only shops or departments, leaving the routing within every department to its despatcher or to its move-man (see section 68).

99. Importance of basic records. The instruction cards and the Requisitions have the important function of serving as the original and basic records of the progress of orders and of the

use of materials and labor. All later summarized and office records are built upon these and cannot be any more accurate than they are. Therefore accuracy must begin with them. It is useless to build a refined office system on fundamental shop records which are unreliable. There must be competent clerks to keep the records. The student should clearly realize this; for clerical work is a sort of bugaboo to many managers, and they scrimp on it unwisely and uneconomically.

100. Final disposition for requisitions. The routing of the different copies of the material requisitions will vary somewhat, according to circumstances, but each must soon reach the officer for whose information it is intended. The copy which went to the storerooms is forwarded to the Central Planning Office and there furnishes the data for the credits which the stock clerk enters on his perpetual inventory as the amount of material delivered (see section 116).

The Paymaster's copy should be filed against the worker to whom the material was issued. This card adds to this file the record of the worker's efficiency in the use of materials. The Cost Accountant's copy should be filed against whatever designation is most suitable to the cost system (see section 93). The planner's copy should be filed against the Job Order Number (see section 121, "Detail Record of Progress," and Fig. 22) in the "jacket" for the job (see section 118).

101. Displacing old methods. The instruction cards and the Requisitions for materials may displace old methods which imperfectly accomplished the same purposes. **In any such case it is important that the old methods should be continued until the new have been thoroughly tested and the organization has learned to handle them.** When this stage has been reached, the old methods can be discontinued.

102. Work on which Planning is dependent. In order that planning may be done accurately, the times necessary for operations — that is, the Standard times — must be known. The determination of these is discussed in Chapter XIII, Standards, beginning with section 301. In order that Standard times may be realized, there must be Adaptation of Conditions and Work to each other, work must be done by Correct Methods, and the workers must have an Efficiency Reward for approximating the Standard times. Progress in the application of the principles

here mentioned must accompany the development of Planning and Despatching.

103. Error in the plans. At first there will be considerable error in the plans laid down by the Central Planning Office; and this error should be continually reduced as the improvements mentioned are made, although it can never be absolutely eliminated. One of the main reasons for the use of the methods of departmental Planning and Despatching above described is that this error may be corrected by persons having that intimate knowledge of details which results only from close contact with the work. It is also necessary that the Central Planning Office should be continuously and promptly informed of the actual facts, and should revise its main outline plans accordingly. It is for this reason that all outstanding Instruction Cards should be closed out at the close of every day or shift, and that all Instruction Cards which record events during that day or shift should be forwarded to the Central Planning Office as soon as possible thereafter.

104. The Master Schedule, or Standard-Operation Sheet. It is evident that in order to obtain a coincidence of events as to time it must be known how much time will be required to produce these events. Time studies are the ordinary means of obtaining this knowledge. In addition, the events themselves must be analyzed into their elements, which in this case are the shop operations.

105. Example of Master Schedule, or Standard-Operation Sheet. The elements of time and events must then be synthesized into the Master Schedule, of which an example is shown in Table VII on pages 134–135. Obviously the exact form of the schedule in any case depends upon the work in hand.

The third column of Table VII, Remarks, is for such miscellaneous information useful to the planner as can conveniently be embodied in the schedule.

Under "Complete slide cores, and veneers as slides," operation "Taking out cauls," the Standard times are marked as doubtful. This means that the times given may be used in planning, but must not be used as a basis for the payment of Efficiency Reward (except special forms of Efficiency Reward, adapted to uncertain Standards) until they have been confirmed.

Under "Slide Veneers," operation "Cutting Off," no standard time is given, as it is represented as not yet determined. If

a schedule is otherwise ready to go into use in planning, a few gaps in the standard-time column should not be allowed to delay its use. Such gaps may be filled in, when occasion arises, by the foreman's guess at the time required, if no better information is available, rather than to allow a long delay in getting the benefit of the parts of the schedule already determined.

106. The Analysis File. Everything that the planner can know about the operations, the product, the materials, the tools, the men, and the shop is useful to him. Very much of this information — much more than can be embodied in the schedule — is worth recording in permanent and convenient form. The forms in which, and the origins from which, this information reaches the planner are so various that it is hopeless to try to standardize its form. It is a good plan, therefore, to file the master schedules in large envelopes and, as drawings and other information valuable to the Planning Office are acquired, to file these in the envelope containing the master schedule of the part or article to which they chiefly refer. If any such piece of information refers to several parts or articles, it may be most efficient either to have copies of it made to file with all their master schedules or else to file it with the master schedule to which it most applies. Then file cross references with the other master schedules affected. This collection of master schedules and of information pertaining to them is called the Analysis File.

The time studies by which were determined the standard times shown at the right of the schedule should be kept on file, but any schedule of the form shown in Table VII would be swamped by filing with it all the time studies involved. It is usually better to keep the time studies in a separate file, so arranged and classified that the time study relating to any operation on any part can be readily found when wanted.

107. Symbolizing. At the time the master schedule shown in Table VII was made out, the work of symbolizing had not advanced very far. The schedule is shown in this form because it should be put into use as an aid to planning without waiting for the development of a complete symbol system. Of course, operations, parts, partial and full assemblies, and machines ought to be denoted by definite symbols as soon as these can be worked out without taking time from other things of more importance. A sufficient reason for this is that the names which

TABLE VII. MASTER SCHEDULE, OR STANDARDIZED OPERATION SHEET (A)

Operation	Equipment In order of preference	Remarks Make slides to stock
Gluing up	Linderman, No. 1	671, 673, 674 — $20\frac{1}{2}''$L x 22″ 672-$16\frac{1}{2}''$L x 22″
		L = Length fed through Linderman
		Every piece thus glued up makes
		2 slide cores
Ripping	Ripsaw, No. 89 or	Rip $20\frac{1}{2}''$ x 22″ next above into two 10″ x 22″
	Ripsaw, No. 98	Rip $16\frac{1}{2}''$ x 22″ next above into two 8″ x 22″
Cutting to length	Ripsaw, No. 89 or	Standard time is for all three operations
	Ripsaw, No. 98	at one handling; plan accordingly
Cutting	Ripsaw, No. 89 or	Either saw may be used as well
	Ripsaw, No. 98	as the other
Stiling	Linderman, No. 1	All stiles 22″ long. Stiles from stock
Heading	Linderman, No. 1	671, 673, 674 — Heads $12\frac{3}{8}''$ long 672-head $10\frac{3}{8}''$ long
		Heads come directly from stock
Planing both sides	Surfacer, No. 76	
Sanding	Sander, No. 9	
		Complete cores go to Veneer Room
Cutting off	Cross-cut saw, No. 248	
	Any cross-cut saw	
Ripping	Ripsaw, No. 201	
	Any ripsaw	
Drying	Veneer heater, No. 202	
Joining	Veneer joiner, No. 203	
Laying up		
Taping	Veneer taper, No. 204	
Gluing joints	Veneer joint gluer, No. 205	
Gluing	Glue spreader, No. 206	Assembly of cores and veneers. Standard
Racking up for press		time includes racking up to dry but not
Pressing	Glue press, No. 207	drying
Racking up to dry		
Drying in open air		Standard time is for drying only
Taking out cauls		Both operations to be done at one
Stamping with 3 marks		handling
Jointing	Jointer, No. 57 or	Either jointer may be used as well as
	Jointer, No. 63	the other
Ripping	Ripsaw, No. 89 or	Either saw may be used as well as
	Ripsaw, No. 98	the other
Setting up D.E. saw, No. 60	D. E. saw, No. 60	Set-up with ripsaws
D. E. Cut off	Tenon machine, No. 58	
	D. E. saw, No. 60	
Boring	Boring machine, No. 74	
1st Sanding	Sander, No. 9	Standard time is for both operations at one
2nd Sanding	Sander, No. 9	handling, plan accordingly
		Slides go to 2nd floor
Polishing	Matteson polisher, No. 301	
	Polisher, 307	
3rd Sanding	Hand sander, 347 or	Either sander may be used as well
	Hand sander, 348	as the other
		Slides return to first floor
Shaping	Shaper, 117	Putting hand grip on slides
	Shaper, 71	
		Slides go to Cabinet Shop

TABLE VII. MASTER SCHEDULE, OR STANDARDIZED OPERATION SHEET (B)

Part	Standard Time (In hours per 100 articles of finished product unless otherwise noted) — Designation Number of Finished and Assembled Articles 671	672	673	674
	61	1.22	1.22	1.22
Slide cores				
	.57	1 13	1.13	1 13
Slide stiles and cores as stiled cores	.31	.62	.62	.62
	31	.62	.62	.62
Slide heads and stiled cores as complete slide cores	13	.26	.26	.26
	.06	.13	.13	.13
	.81	1.38	1.62	1.62
Slide veneers				
	.22	45	.45	45
	17	25	.34	34
	45	.9	9	.9
	21 hours of elapsed time regardless of size of lot			
	39?	79?	.79?	79?
	32	64	64	64
	55	1 11	1 11	1 11
	3	.6	6	6
	19 hour for main set-up, plus 19 hour for every change of saws, plus 095 hour for every change of length; regardless of size of lot			
Complete slide cores, and veneers as slides	.21	43	.43	.43
	.22	.44	.44	.44
	21	.41	.41	.41
	.27	.54	.54	.54
	.41	.37	.82	.82

grow up naturally for operations and parts are not uniform, even in different parts of the same plant. Consequently orders given in terms of those names have not such clearly defined meaning as is desired.

108. Job Schedules. Thus far, in the installation of Planning and Despatching, the only thing in the way of a definite dated program of work is the Order of Jobs, which gives only the final date of delivery of the principal jobs from the plant. It is now proposed to develop central planning so that the schedule of any order through the plant shall be predetermined in much more detail. The student should appreciate the importance of the matter. To that end the following quotation is given from a lecture delivered by C. F. Tollzien, Manager of Production of the Packard Motor Car Company, to that company's foremen in its Advanced Training School.

WHY KEEP UP THE SCHEDULE?[1]

I want to impress upon you the importance of your jobs in keeping your production of each and every part up to schedule; for this accepted manufacturing program is the only basis upon which the company can produce finished vehicles, — its finished product for sale to our customers. The effect of our manufacturing program is far-reaching: the Management of the Company accepts it without cavil, once it is established, and it proceeds to finance the Company to carry out that program; the expenditures of the Company for material are based upon this program; the force throughout the factory is adjusted upon the basis of this program; the estimate of the expenses to meet the semimonthly pay roll is made in accordance with this program. In fact, the value of every dollar that the Company has and the productive capacity of every man whom the Company employs is staked upon this program. It must therefore be a program which is definite and accurate to begin with, and which is subsequently carried out to the letter.

Failure to be Prompt spells Disaster

Our Sales Department allots vehicles to our branches and to our dealers upon the basis of the program; the branches and the dealers finance themselves on the same basis; they employ their salesmen, and they instruct their salesmen to go out and sell, and promise deliveries, on the basis of the program; the customer buys upon that

[1] Reprinted from "Advanced Training-School Lecture Course," by permission of the Packard Motor Car Company, Detroit. Copyright, 1919.

promise, and he expects to get the delivery of his vehicle according to the promise of the salesman. He gauges his own business upon that promise: he signs contracts, he invests his own money, he places himself under obligation, upon his expectation that he will have transportation facilities at hand at the time promised by the Packard Motor Car Company with which to carry on his business. Therefore we cannot afford to establish a program which is accepted in good faith by our Company, our branches and dealers, our distributing points, and our customers, and we ourselves fail to live up to it.

We all know that a Packard car or a Packard truck requires the requisite number of each and every piece. We all remember occasions when delay in a simple screw machine job has held up the assembling of cars and trucks. Each little piece is just as important to the complete vehicle as the big pieces. Therefore we must not be satisfied in selecting out the larger parts in our schedule and gauging our productive success on our ability to maintain scheduled production on these parts alone. We have found too many times that this tendency does not bring results. We must be ever watchful of each detail, each part, big and little; and that is the reason why our departmental schedules cover each and every part — just so they may be watched. It is the degree of care and watchfulness exercised by each Foreman on each part in his department, and the production of it according to the schedule, which determines the likelihood of our making the shipment at the proper time. Therefore we urge you to watch them all continually. Watch yourselves, your machines, your tools, your men, all the conditions affecting the work of your department. Careful watching, coupled with good common sense, will bring the job through with 100 per cent efficiency record.

There is only one way in which this account may be kept straight, and that is by accurate records and by the figures as shown on the schedule; and we must insist upon the production of every department of this Plant being controlled entirely by the schedules, because only in this way can the production in each department be gauged, and the various pieces be brought through at the proper rate and proportion to come down through the line and meet at the proper place and thus provide the requirements of the chassis-assembling line at the right time; only by so doing will we be able to produce the finished vehicle on an economical basis.

Follow Schedule, and Coöperation is Inevitable

Now this calls for coöperation, and the amount of coöperation shown is a sure indication of the interest which you and I have and which all the men in this Plant have in their jobs, focussed on a single standard achievement. And if each of us does focus his